DOE/MC/31175 -- 5229
(DE96011333)

Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products

Quarterly Report
November 1994 - February 1995

March 1995

Work Performed Under Contract No.: DE-FC21-94MC31175

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
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Pittsburgh, Pennsylvania 15261

Disclaimer

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EXECUTIVE SUMMARY

During the second quarter, twenty-five by-product samples were collected. Thirteen partial and five comprehensive analyses, four digestions for total metals, and nine TCLP and six ASTM extractions were applied to by-product samples. Eleven characteristic metal-laden hazardous wastes were examined, six of which have proven to be suitable for use in the project. Exploratory treatments of fifteen waste/by-product combinations were initiated. Further background documents have been identified and the two white papers extended. Plans have been developed to collect a large sample of the Tidd by-product, because this unique demonstration facility will be permanently shutdown sometime during the coming quarter.

Material Acquisition

Dravo Lime Company (DLC) has collected ten samples from Anker Energy Corporation, six samples from CONSOL, nine samples from Ebensburg Power Company (EPC) and seven samples from the Tidd Station. Approval to use the Tidd by-product was received but discussions are still on-going with CSX regarding use of the AES Thames by-product. Early in the third quarter a fifty-ton sample will be collected from Tidd into two pneumatic tanker trucks and transferred into approximately fifty super-sacks at a bagging facility in Indiana at a cost estimated at about $6,900.

Mill Service, Inc. (MSI) has identified six characteristic metal-laden (all in fact being principally lead-laden) hazardous wastes. They are

- industrial wastewater treatment residue from a battery manufacturing plant
- contaminated soil from a remediation project conducted at a munitions depot
- contaminated soil from a remediation project conducted at an abandoned industrial site
- contaminated soil from a remediation project conducted at a former sewage treatment plant
- air pollution control dust from basic oxygen furnace steel production
- air pollution control ash from municipal waste incineration.

Material Evaluation

The totals for the geochemical analyses by DLC of five by-product samples ranged between 96.13% and 100.33%, which is the usual variation expected. The variation in physical properties and reactivity appears so far to be relatively small within each set of by-product samples from the same source. These are very alkaline materials and the temperature during the measurement of their pH is critical.

None of the four by-products exhibited toxicity characteristic metal characteristics based on TCLP extractions of one sample from each source by MSI. However, the level of three or four total metal concentrations exceeded Land Disposal Restriction treatment standards for all four of the samples.

The project team members from the University of Pittsburgh (Pitt) prepared ASTM and TCLP extracts and graphite furnace methods for measuring antimony, beryllium, thallium and vanadium to be utilized during the third quarter.

Waste Treatment

MSI treated 200-gram aliquots of five of the six wastes, deemed to be suitable for study in this project, with the three approved by-products at weight ratios of 1:9, 3:7 and 1:1 (by-product:waste). Analyses are continuing to determine the results of the metals stabilization by these 45 treatments.

Other Activities during the Quarter

Several key documents were added to the project files, including two reports on waste stabilization/solidification (S/S) from EPRI and Environment Canada/EPA and a paper by Babcock & Wilcox describing the EPC boiler. A good start was made on the white paper on "Overview of S/S Processes."

A news release announcing the program is being prepared by Pitt, along with an article for the April issue of the newsletter of the School of Engineering. Material was provided to the project's Contracting Officer's Representative for a Technology Status Report of major projects in the Fossil Energy Waste Management program.

Plans for the Next Quarter

Either approval to utilize the AES Thames by-product will be received or another candidate for the fourth by-product will be identified. Under the first scenario, collection and analysis of all Phase One by-product samples will be completed. A 50-ton sample of the Tidd by-product will be acquired.

Identification and validation of at least two additional wastes will be sought. Laboratory treatments will continue and solidification tests will begin. It is anticipated that nearly twenty solidification tests will be underway by the end of the third quarter.

The computerized data base will be put into operation, initial observations will be made, and the first tentative conclusions will be drawn.

The two white papers will be expanded.

The news release and newsletter article will be issued.

Authorization for the NEPA Report will be sought, the Performance Report will be prepared and the Continuation Application will be submitted.

INTRODUCTION

This second quarterly report describes work during the second three months of the University of Pittsburgh's (Pitt's) project on the "Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products."

Participating with Pitt on this project are Dravo Lime Company (DLC), Mill Service, Inc. (MSI) and the Center for Hazardous Materials Research (CHMR).

The report describes the activities of the project team during the reporting period. The principal work has focussed upon the acquisition of by-product samples and their initial analysis. Other efforts during the second quarter have been directed toward identifying the first hazardous waste samples and preparing for their treatment and analysis. Relatively little data has yet been collected. Major presentation of technical details and data will appear for the first time in the third quarterly report.

The activity on the project during the second quarter of Phase One, as presented in the following sections, has fallen into seven areas:

- Acquiring by-products
- Analyzing by-products
- Identifying, analyzing and treating suitable hazardous wastes
- Carrying out the quality assurance/quality control program
- Developing background
- Initiating public relations

BY-PRODUCT ACQUISITION

At the end of the first quarter the project team was still working toward obtaining approvals for two of the four by-products selected for use on the project. Written approvals had previously been granted by the Ebensburg Power Company (EPC) and CONSOL Inc. for residues from EPC's coal-waste CFBC and from the coal-fired Carney's Point Cogeneration Plant. Oral approval had been received (and written approval requested) from American Electric Power (AEP) to use the cyclone ash from the coal-fired PFBC at the Tidd Station. But it had just been learned that approval for use of the residue from the AES Thames coal-fired CFBC (being collected at the Albright Mine of Anker Energy Corporation) was incomplete.

During the first quarter a total of seven samples were collected from EPC (3), Anker Energy (3) and the Tidd Station (1). Dravo Lime Company (DLC) and the University of Pittsburgh (Pitt) had just begun the first analyses as the quarter closed.

Discussions with By-Product Producers

Tidd Station. In mid-December 1994 two members of the environmental staff of AEP provided written approval for use of the cyclone ash from the PFBC at the Tidd Station in a letter addressed to S. W. Burge, manager of that station (Appendix A).

AES Thames. Throughout the quarter discussions continued with AES Thames and CSX (and its subsidiary, Energy Resources and Logistics, Inc.- ERL). On December 12, 1994 an extensive letter was submitted by the project team to ERL requesting approval for use of the AES Thames by-product in the project. This was followed up with similar letters to AES Thames and JTM on February 9, 1995. In a conversation that day with Mr. Mark Boucher of AES Thames, it became clear that the key concern of AES Thames is indemnification against litigation arising from codisposal of the by-product with hazardous waste in a repository which at some future time is alleged to be in violation of environmental regulations. While AES Thames expects CSX to provide that indemnification, it was suggested that the project consider indemnifying CSX. At the conclusion of the quarter the project team was awaiting a response from CSX.

Collection of By-Product

Phase One Samples. During the second quarter a total of 25 additional samples of the four by-products were collected by DLC. This brings the number of samples in-hand to 32, as detailed in Appendix B. Here is a synopsis of this activity.

Since late October 1994, in the project's first quarter, nine of the ten required samples have been taken from the EPC silo. The fly ash is not kept separate from the bed ash.

However, a small sample of each was collected by the plant to test the available lime index. The silo samples are a blend of bed ash and cyclone ash. A portion of Samples # 2, 3, 4 and 5 were sent to Pitt. Approximately 100 pounds of Samples # 3 and 4 were sent to MSI. No significant problems in sampling occurred to prevent obtaining grab samples of dry ash from the silo that are representative of good operating conditions. The daily operating reports were obtained and passed on to Pitt.

All ten of the required samples of the AES Thames by-product have been taken at Anker Energy's Albright (WV) receiving station, according to the test plan. Samples # 2, 4 and 7 were sent to Pitt. Sample # 4 was sent to Mill Service, Inc. (MSI). Samples of dry cyclone ash were collected underneath the hydrated crust on top of railroad open hopper cars. Car numbers and car loading dates were recorded. Daily operating reports for the time period of ash samples loaded into cars have not yet been sought. As just mentioned, the project team is awaiting approval from CSX to work with this by-product.

Six of the dry spray drier fly ash samples from the Carney's Point power generating plant have been collected at the CONSOL Blackswell receiving terminal near Waynesburg, PA. Samples # 1 through 4 were taken from the same unit train from Carney's Point. Car numbers of the covered hopper cars and dates loaded were recorded. Sample # 1 was sent to Pitt and MSI. The daily boiler operating reports for the time periods of ash samples have not been received. The MSDS has been received for this by-product.

Seven of the ten samples have been collected from the Tidd plant cyclone ash silo. The silo at Tidd has a one-day capacity when the unit is operating at its full rating. The ash from the silo includes the electrostatic precipitator ash. Sample # 2 was sent to Pitt and MSI. Daily operating reports on boiler conditions for the sample time period have not yet been requested. However, verbal communication with plant engineers determined that boiler operations were stable and producing power. The MSDS has been received for this by-product.

Phase Two Sample. The PFBC at the Tidd Station is scheduled to be permanently shutdown by early spring 1995. Therefore with the concurrence of the Contract Officer's Representative the project team has planned the collection of the 50-ton sample of this by-product which will be needed for Phase Two.

The initial thought was to install a new fill nozzle on the silo at Tidd to connect to super-sacks. However, the material in the silo is kept at 300-400°F to assure that no moisture will condense on the ash, which could lead to plugging. The super-sacks cannot tolerate temperatures this high. Therefore it was decided to use the existing elephant trunk to transfer the hot ash to pneumatic tanker trucks, provided by Bulk Transit Company.

Several approaches were considered for transferring the by-product from the tanker trucks to the super-sacks. Two that were discarded were direct filling at the Cardinal Station's disposal site and staged filling from a second silo. The first discarded approach was deemed insufficiently robust and a potential dust emission source too difficult to control. The second failed for lack of an easily obtained suitable silo.

The approach that will be used involves travel of the tanker trucks to a commercial bagger, Aimcor in Aurora, Indiana, which has the capability of removing the ash from the tanker trucks, cooling it, filling the super-sacks and placing them on pallets for transport back to the Pittsburgh area for storage.

The final step in this procedure is the identification of the temporary storage location until the by-product can be used in Phase Two. Both AEP and MSI said they were unable to provide a storage site, so DLC has agreed to clear a portion of a building at their Research Center to house the super-sacks until they can all be shipped to MSI in late 1995 or early 1996.

The cost of collection of the 50-ton sample of PFBC by-product from the Tidd Station is estimated to be $6,846 of which AEP will cost-share $2,000. Approval for collecting the Phase Two sample from Tidd has been received from the Contracting Officer's Representative and the work will be carried out early in the third quarter.

BY-PRODUCT ANALYSIS

By-products have been analyzed during the second quarter by all three of the principal participants in the project.

Analyses by Dravo Lime Company

Test results for three of the nine EPC samples plus the bed ash and fly ash samples are given in Appendix C, which includes the results of all of DLC's by-product analyses. Tests for specific surface area (SSA) and particle size distribution (PSD) are not compete. Sample # 2 was given the "complete" or comprehensive analysis. The geochemical analysis for this sample, calculated to the oxide form, totals 97.30%. The geochemical analyses for Samples # 3 and 4, given to MSI, are not complete.

Seven of the AES Thames samples have been analyzed except for SSA and PSD. The geochemical analyses for Samples # 2 and 4 totalled 96.13% and 96.36% respectively.

Four of the CONSOL samples have been analyzed except for SSA and PSD. Only Sample # 1 has received a complete analysis so far.

Sample #2 from the Tidd Station was given a complete analysis and Samples #1, #3 and #4 were given partial analyses.

A detailed discussion should be deferred until all samples have been tested. However, a few general observations can be made.

1. By visual observation, all samples from each source appear to have the same physical appearances, i.e., color and texture.

2. So far, no large variation can be seen within each source in physical properties, such as specific gravity (g/cc) or bulk density (lb/ft^3).

3. So far, no large variation can be seen within each source in the "reactivity" and neutralization parameters, such as available lime, calcium carbonate equivalency (CCE) and mixed ratio (solidification of water). The amount of CCE as percent $CaCO_3$) appears to correlate with the available lime index. The amount of total CaO due to unspent calcium carbonate sorbent can be judged from the amount of CO_2 reported.

4. The totals for the geochemical analysis of major elements calculated to the oxide bases are close enough to 100%. (The total is arrived at by adding CaO, MgO, SiO_2, Fe_2O_3, Al_2O_3, SO_3, SO_2 and loss on ignition [LOI at 1100°C].) Minor elements, such as Na, K, Ti, Mn, P and unburned carbon, were not analyzed.

5. Some pH's of EPC and AES Thames by-products were over 12.50, which will cause concern. The pH of lime solutions can exceed 12.50 as the temperature cools below 25°C.

6. Based on the mixed ratio test, all the samples of the four sources show solidification potential, and due to the free or available lime and silica, they all have potential to stabilize heavy metals. The question is how well can they stabilize, and that of course will be answered in the third quarter.

Analyses by Mill Service, Inc.

Mill Service collected representative aliquots from the following by-product samples provided by DLC for use in the Phase I waste treatment studies:

- AES Thames # 4
- CONSOL # 1
- EPC # 3
- Tidd # 2

A 100-gram portion of each aliquot was extracted according to the TCLP protocol (SW846, Method 1311). The extract generated for each by-product was then distributed into two 1-liter sample bottles and preserved with nitric acid for subsequent analysis. Antech, Ltd. and Pitt were each provided with one of the 1-liter extract samples of each by-product. In addition, each laboratory was provided with a 250-gram sample of each by-product (part of the representative aliquot originally collected) for analysis. Analytical request forms accompanied the samples to the laboratories. The forms identified the parameters to be analyzed, the analytical methods to be used, and the detection levels to be achieved. A sample of the analytical request forms used for this purpose are provided in Appendix D.

The results of the by-product analyses performed by Antech, Ltd. are tabulated in Appendix E. The results of the by-product analyses performed by Pitt have not been reported. None of the by-products exhibited any of the toxicity characteristic metal characteristics based on the TCLP results.[1] Each of the by-products did contain some metals at concentrations greater than or equal to 20 times the toxicity characteristic limits or greater than or equal to 20 times the Land Disposal Restriction (LDR) treatment standards.[2] Metal concentrations at these levels are of concern due to the potential that they will contribute to the extractable metals concentrations in the treated waste samples generated during the

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[1] All of the TCLP results were reported below the analytical detection level except for As in the EPC #3 material.

[2] A safety factor of 0.8 was used to evaluate the data.

waste treatment portion of this project. The parameters of concern in each of the by-products are:

- AES #4 (Ba, Cr, Hg, Ni)
- CONSOL #1 (Cd, Cr, Hg)
- EPC #3 (As, Ba, Cd, Cr, Hg)
- Tidd #2 (As, Ba, Cd, Cr)

<u>Analysis by the University of Pittsburgh</u>

As a trial run of extraction, a sample of ash that was obtained from another project being conducted at Pitt was extracted by both the ASTM and TCLP protocols. Also in preparation for beginning analyses for metals in extracts and digestates, a spiking solution was prepared. This solution contains all RCRA metals except silver, plus Cu, Ni and Zn. Silver was found to precipitate from the chloride salt solution.

Six by-product samples (AES # 2, 4, and 7, CONSOL # 1, EPC # 2, 3, 4 and 5, and Tidd # 2) were extracted by the ASTM protocol and five by-product samples (AES # 2 and 7 and EPC # 2, 4 and 5) were extracted by the TCLP protocol. Extracts of four same samples (AES # 4, CONSOL # 1, EPC # 3 and Tidd # 2), obtained using the TCLP protocol, were received from MSI. Analyses of the eleven extracts prepared at Pitt were begun. Appendix F presents the results obtained during the second quarter. Further analyses of all fifteen extracts will be conducted in the third quarter.

During the second quarter discussions and plans for possible by-product digestion at Pitt have been developed. Previous digestions of ash on another project at Pitt have been made using the sodium carbonate procedure. MSI's subcontractor performs digestions using the same method. After the treatment with alkali, the resulting material is neutralized with acid. The usual acid is hydrochloric. But several metals, including one of interest to this project, thallium, have volatile chlorides. Therefore, to analyze for thallium, a portion of the alkaline mass must be separated and neutralized with an alternative acid. By-product digestion for total metals analysis will likely be performed at Pitt during the third quarter using this technique.

IDENTIFICATION AND TREATMENT OF SUITABLE HAZARDOUS WASTES

During the second quarter MSI evaluated eleven characteristic metal-laden hazardous wastes for use in the project. Five of the wastes were determined to be unsuitable and six were determined to be suitable. Laboratory treatments of five of the suitable wastes with the three approved by-products were performed. The laboratory treatment of the sixth suitable waste remains to be performed.

Identification of Suitable Hazardous Wastes

MSI evaluated 11 characteristic metal-laden hazardous wastes for use in the project. Included were two industrial wastewater treatment plant residues, six contaminated soils, two air pollution control dusts, and one sandblast waste. 250-pound samples of each waste were obtained from the generators of the waste or collected from shipments of the waste received at the MSI Yukon TSD facility. A representative aliquot of each waste was then removed for analysis. A 100-gram portion of each aliquot was extracted according to the TCLP protocol and the extract generated for each waste was then distributed into two 1-liter sample bottles and preserved with nitric acid for subsequent analysis. One of the extract samples was then delivered to Antech, Ltd. for analysis to determine if the waste exhibited the expected hazardous waste characteristic(s). Five of the wastes sampled were disqualified from use in the project on the basis that analysis of their TCLP extracts did not verify that the wastes exhibited the expected hazardous waste characteristic(s). On this basis, six of the wastes qualified for use in the project. The wastes that qualified, and the hazardous characteristics exhibited by each, were:

Waste	Characteristic(s)
Industrial Wastewater Treatment Residue from a Battery Manufacturing Plant	Lead
Contaminated Soil from a Remediation Project Conducted at a Munitions Depot	Lead
Contaminated Soil from a Remediation Project Conducted at an Abandoned Industrial Site	Lead
Contaminated Soil from a Remediation Project Conducted at a Former Sewage Treatment Plant	Lead
Air Pollution Control Dust from Basic Oxygen Furnace Steel Production	Lead

Air Pollution Control Ash from Municipal Waste Incineration	Lead

The samples of the disqualified wastes that had been collected for possible use in the project were subsequently treated at the Yukon facility and disposed in accordance with the facility's permits.

Mill Service then authorized Antech to perform the remaining analyses on the TCLP extracts generated from the qualified wastes and provided Antech with a 250-gram sample of each of these wastes (part of the representative aliquot originally collected) for total metals analysis as well. Pitt was also provided with a 1-liter TCLP extract sample and a 100-gram sample of each waste for analysis. Analytical request forms accompanied all samples to the laboratories. The forms identified the parameters to be analyzed, the analytical methods to be used, and the detection levels to be achieved. A sample of the analytical request forms used for this purpose are provided in Appendix D.

The results of the waste analyses performed by Antech, Ltd. are tabulated in Appendix E. The results of the waste analyses performed by Pitt have not been reported. None of the wastes exhibited any other toxicity characteristics than are identified above. However, each of the wastes did contain some metals at concentrations greater than or equal to 20 times the toxicity characteristic limits or greater than or equal to 20 times the Land Disposal Restriction (LDR) treatment standards. Metal concentrations at these levels in the wastes are of concern due to the potential that they will leach under the altered conditions present in the treated waste samples generated during the waste treatment portion of this project. The parameters of concern in each of the wastes are:

- Industrial Wastewater Treatment Residue from Battery Manufacturing Plant
  Cd, Pb.

- Contaminated Soil from a Remediation Project Conducted at a Munitions Depot
  Ba, Cd, Cr, Pb, Zn

- Contaminated Soil from a Remediation Project Conducted at an Abandoned Industrial Site
  Ba, Cd, Cr, Pb, Hg, Zn

- Contaminated Soil from a Remediation Project Conducted at a Former Sewage Treatment Plant
  Pb (Others to be determined)

- Air Pollution Control Dust from Basic Oxygen Furnace Steel Production
  Cd, Cr, Pb, Ni, Zn

- Air Pollution Control Ash from Municipal Waste Incineration
  As, Ba, Cd, Cr, Pb, Hg, Ni, Se, Ag, Zn

Treatment of Suitable Hazardous Wastes

Five of the characteristic metal-laden hazardous wastes determined to be suitable were each treated during the quarter with the three approved by-products at weight ratios of 1:9, 3:7 and 1:1 (by-product:waste). A small quantity of water was used in most of the treatments. All of the treatments were conducted in the Yukon facility laboratory using 200-gram aliquots of waste in each treatment. Following the completion of the treatment batch, a 100-gram portion of the waste/by-product mixture was removed and extracted according to the TCLP protocol. The extract generated was then distributed into two 1-liter sample bottles and preserved with nitric acid for subsequent analysis. This procedure was repeated for each of the waste/by-product mixtures 24 hours after the completion of the treatment batch. One of each of the extract samples was then delivered to Antech, Ltd. for analysis to determine if the waste/by-product mixture continued to exhibit the hazardous waste characteristic(s) exhibited by the untreated waste, exhibited any other hazardous waste characteristics based on the parameters of concern identified from the total metals analyses performed on the waste and by-product, and to determine if the waste/by-product mixture achieved the LDR treatment standards. The extract samples prepared for Pitt were not delivered pending the results of the total metals analyses being performed by that laboratory on the wastes and by-products. Analytical request forms accompanied the samples to the laboratory. The forms identified the parameters to be analyzed, the analytical methods to be used, and the detection levels to be achieved.

The results of the analyses were not reported to MSI during the quarter. These results will be included in the next quarterly report.

QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

There are two basic elements of the project's QA/QC Program - chain of custody and the use of spiked, control and blank samples.

Chain of Custody

Samples of both by-products and hazardous wastes are being drawn, labeled, shipped and received under a strict logging system to assure that each sample is properly identified, analyzed and utilized throughout the project. Digestates and extracts are similarly being produced, labelled, shipped and received to make certain that analytical results are accurately attributed to the proper material.

Blanks, Controls and Spiked Samples

Quality Assurance/Quality Control was practiced during all laboratory analysis by the use of blank samples, spiked blank samples, spiked blank samples, and duplicate samples. As an example, at Pitt blank samples were carried through both the TCLP and ASTM extraction procedures. The blank samples for the TCLP extractions were simply the acetic acid extraction fluid, and the blank samples for the ASTM extractions were deionized water. Blank samples were prepared in order to indicate any contamination of the sample batches that may have occurred during the laboratory procedures. Spiked blank samples were prepared by spiking the appropriate extraction fluid with 50 ml of a spiking solution that contains the metals of interest (with the exception of silver). The purpose of the spiked blanks was to ensure that no losses of the metals of interest occurred either by physical or chemical means during the laboratory procedures. Duplicate samples were prepared in the same manner as the original sample for the purpose of measuring the reproducibility of the laboratory procedures.

At Pitt, in addition to the above QA/QC measures, a spiked TCLP sample was prepared using the EPC by-product. Subsequent analysis of this extracted yielded metal concentrations far less than expected, probably due to precipitation of the metal species as the pH of the leachate rose. As a result, the practice of spiking samples during the leaching portion of the laboratory procedures will not be continued. Spiking samples will only be performed during the digestion phase of the procedures, where the low pH will prevent precipitation of the spiked metals.

At Pitt, all QA/QC data obtained to date indicate that there has been no problem with the analysis so far. Blank metal concentrations were low as expected, spiked metal concentrations were close to those concentrations of the initial spike, and duplicate metal concentrations were close to the original sample concentrations.

DEVELOPMENT OF BACKGROUND

A number of documents have been added to the project's library and additional material has been developed for white papers on by-products and hazardous wastes.

New Documents

Members of the project team have had discussions and visits with staff of the American Coal Ash Association and the Electric Power Research Institute. These contacts, and other sources as well, have yielded a number of new references and documents to the project's files, including:

- Discussion on the internet on December 5 and 6, 1994 on hazardous waste methodology by David Kurland, Regulatory Counsel, Rohm and Haas Company.

- Environment Canada/EPA Report EPS3/HA/8 (January 1991) on "Investigation of Test Methods for Solidified Waste Evaluation - A Cooperative Program."

- EPRI Report # TR-103958 on "Organic and Inorganic Hazardous Waste Stabilization Using Coal Combustion By-Product Materials."

- "Properties of Pressurized FBC Ashes."

- Bibliography on flue gas desulfurization from the U.S. Bureau of Mines, dated October 1993.

- Paper presented to the 10th Annual Fluidized-Bed Conference of the Council of Industrial Boiler Owners by S. Kavidass on "Technology Evaluation for a Waste-Fuel-Based Circulating Fluidized-Bed Project," which describes the Ebensburg Power Company unit in significant detail.

Additions to White Papers

The white paper on "Characterization of Advanced Clean Coal Technology By-Products" has been augmented somewhat with introductory and summary material at the beginning of sections on "By-Product Characterization," "Mineralogical Properties," "Physical Properties," and Leaching Properties." A new summary has been placed just before "Conclusions," a new cited reference and 18 new un-cited references have been added. The revised paper is presented in Appendix G.

The first draft of a white paper on "Overview of Stabilization/Solidification Processes" has been prepared and is presented in Appendix H.

ADMINISTRATIVE ASPECTS

This section contains discussions and references to several administrative aspects of the project.

Public Relations

Two avenues toward publicly announcing the project were followed during the second quarter.

On November 22, 1994 the Principal Investigator met with two members of Pitt's public relations activity to present them with a draft news release. The quarter ended before any action by these two individuals.

On January 6, 1995 the Contracting Officer's Representative requested information to add to a description of the project in a Technology Status Report covering the status and accomplishments of major projects in the Fossil Energy Waste Management program. The requested information was provided on January 11, 1995 and a draft of the portions of the report pertaining to the project was received for review on February 13, 1995. The review was still in process as the second quarter ended.

Monthly Highlights

Here are the highlights of the second three months of the project.

November 18 - December 18, 1994

- Ten by-product samples are collected.
- Visit is made to the Yukon Plant of MSI and detailed plan is developed for work by MSI and its subcontractor.
- Test extraction of fly ash is conducted at Pitt.
- Draft news release is prepared.

December 18, 1994 - January 18, 1995

- Eight by-product samples are collected.
- Approval for use of the PFBC by-products is obtained from American Electric Power Company.
- Six candidate wastes are identified by MSI.
- ASTM and TCLP extractions of four by-products are conducted at Pitt.
- Visit is made to American Coal Ash Association.

January 18 - February 18, 1994

- Five by-product samples are collected.
- Final plans are made for collecting the Phase Two sample of the PFBC by-product from the Tidd Station.
- Five wastes are determined by MSI to be suitable; laboratory treatments using three approved by-products are carried out by MSI.
- First AA analyses of project extracts are conducted at Pitt.
- Communication is established with the Electric Power Research Institute.

Comparison of Progress with Milestone Chart

No tasks were scheduled for completion during the second quarter of Phase One and none were finished during this period. By submitting the first quarterly report on November 16, 1994, the project team met its only requirement for this reporting period.

The collection of the by-product samples by DLC has progressed very well during the second quarter of Phase One. Only eight of the total of forty samples are yet to be obtained by DLC. Sufficient by-product has been delivered to MSI to carry out all Phase One treatments. Planning is complete and action is immanent on the collection of the Phase Two sample from the PFBC at the Tidd Station. Unfortunately, we are still seeking approval for use of the fourth by-product, the residue from AES Thames.

The identification of wastes is proceeding well. Five of the materials identified so far have been determined to be suitable for the project - half of the number needed eventually. Laboratory tests of fifteen of the forty by-product/waste combinations have begun. The project team feels that the work required for Phase One has a good chance now of being completed in the allotted twelve months for this portion of the contract.

Meetings, Telephone Conversations and Visits

Reports of meetings, telephone conversations and visits during the second quarter are given in Appendix I.

It should be pointed out that these reports are comparable to draft minutes presented for approval at meetings. Thus they are subject to revision in the following quarterly report. Thomas King of Energy Resources and Logistics, Inc. (ERL), a subsidiary of CSX, has asked that the following changes be made in records in the first quarterly report that relate to the potential by-product from "AES Thames," which is the usual appellation for this facility.

- ERL became associate with AES Thames in the 1980s.

- There are numerous contracts in force in association with the entire AES Thames project.

- CSX has the basic contract to supply coal and limestone and to take away the by-product.

- AES Thames as generator has the responsibility for assuring that the by-product represents no hazard in any way, but CSX by contract indemnifies AES Thames to this effect, subject to approval by AES Thames.

- Anker Energy company and Patriot Mining Company as operators of an ash disposal site have always been subject to these terms of the CSX contract with AES Thames. However, in the earlier part of the 1990s, there was a more relaxed association among generator, transporter and disposer. Close familiarity with contractual terms and conditions was not given attention.

In consideration of the foregoing, many of the statements of the record of the telephone conversations on October 21, 1994 with Mr. King (page 37 of the first quarterly report), on October 26, 1994 with Mr. James (page 38) and on November 9, 1994 with Mr. King (page 41) are somewhat inaccurate. In addition, the two sentences referring to AEP in the record of October 21, 1994 (page 37) could not have been part of that conversation and should be excised completely.

PLANS FOR THE NEXT QUARTER

The activity on the project during the third quarter of Phase One will fall into five major areas:

- Collection and analysis of by-products
- Collection, evaluation and treatment of hazardous wastes
- Data assembly and evaluation
- Literature survey and background development
- Administrative activities

Collection and Analysis of By-Products

The final nine Phase One samples and the Phase Two sample from Tidd will be collected by DLC. It is anticipated that all of the required by-product analyses called for by the Test Plan, will be completed.

Discussions will continue with Energy Resources and Logistics, Inc. toward approval of the use of the AES Thames by-product in the project. If approval cannot be obtained, an alternate fourth by-product will be sought. Currently, the Airpol material is the leading candidate for this role.

Collection, Evaluation and Treatment of Hazardous Waste

MSI will continue to seek the final four wastes for the project among those that are considered for commercial treatment at the Yukon Plant. It is anticipated that at least two other suitable wastes will be identified during the third quarter.

Laboratory treatments will continue using the six wastes already deemed suitable and three approved by-products. It is anticipated that at least ten additional waste/by-product combinations will be examined at this scale during the third quarter. It is further anticipated that the stability of all of the fifteen waste/by-product combinations currently being examined and several of the new ones will be fully evaluated and their solidification tests will be in progress by the end of the third quarter.

Data Assemblage and Evaluation

The Quatropro data base will be established for all by-product and waste analyses and treatment results. Representative charts and figures containing this data will be generated.

Initial observations and conclusions will be provided in the third quarterly report, due on June 17, 1995.

Literature Survey and Background Development

The two white papers will be expanded. In particular, process-specific information relating to the four plants producing by-products will be sought and recorded.

Administrative Activities

The news release and newsletter article will be issued.

Proposals will be made to continue the project beyond Phase One and to begin the environmental impact analysis of Phase Two.

APPENDIX A

APPROVAL FOR USE OF AEP BY-PRODUCT

AMERICAN ELECTRIC POWER

Date December 21, 1994

Subject Experimental Ash Utilization Project

TEW

From T. E. Webb/ S. J. Buckley SJB

To S. W. Burge

Today we spoke briefly about the experimental ash utilization project involving Tidd plant by-product. The two-year U.S. DOE-sponsored project, "Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products" will study the treatment of ten characteristic RCRA metal-laden hazardous wastes utilizing four clean coal technology by-products. The study will be conducted by the University of Pittsburgh and will involve Dravo Lime Company and Mill Service, Inc. We are in full support of the involvement of Tidd Plant to supply by-product for this experimental project and have received management's approval for a variance to the ash utilization policy.

The project will consist of two phases. The first phase is a laboratory study which will require three 15-gallon and seven 5-gallon samples of Tidd by-product. The second phase is a commercial test at Mill Service, Inc. which will require approximately 50 tons of Tidd by-product. The by-product samples will be collected by Dravo Lime Company for both phases of the project. As we understand it, Joel Beeghly of Dravo Lime has already collected a portion of the phase one samples. We appreciate the assistance you gave Joel in obtaining these samples and request that you continue this support during the phase two sampling. According to Joel, this phase will involve containerizing the 50 tons of ash into individual 1 yd^3 "super sacks".

Joel Beeghly also requested that AEP store the containerized 50 ton sample for up to one year on-site at Tidd then provide transportation of the ash to Mill Service, Inc. Pursuant to our conversation, we will notify Mr. Beeghly (by copy of this memo) that the storage of the ash is not possible due to the unavailability of space; however, Tidd will cooperate with Mr. Beeghly to transport the ash for storage at another location.

Finally, Mario Marrocco has approved the idea of charging the packaging and shipping costs associated with the R&D project against the Tidd PFBC account.

If you need any assistance or further information please call either me at 200-1266 or Susanne Buckley at 200-1265.

cc: J. Beeghly - Dravo Lime Company
J. T. Cobb - University of Pittsburgh
H. J. Humphrey - AEPSC
M. Marrocco - AEPSC
A. R. Wood - AEPSC

Intra-System

APPENDIX B

LISTING OF BY-PRODUCTS COLLECTED DURING THE SECOND QUARTER

Second Quarter Project Period

November 18th, 1994 thru February 18th, 1995

Sampling Report: Samples Retrieved for Treatment of Metal-Laden Hazardous Waste with Clean Coal Technology By-Products

By-Product I.D. No.	Sample Date	Location	Rail Car Number	Ship Date	Sample Quantity	Samples Sent to Pitt	Samples Sent to Mill Ser.
AES Thames River #1 (Lab #94-3863)	10/17/94	Albright Mine	NAHX 97209	9/21/91	1 - 5 Gal	-----	-----
#2 (Lab #94-4209)	11/10/94	Albright Mine	CSXT 804949	10/14/94	6 - 5 Gal	Yes	-----
#3 (Lab #94-4210)	11/10/94	Albright Mine	CSXT 813614	9/15/94	2 - 5 Gal	-----	-----
#4 (Lab #94-4773)	12/1/94	Albright Mine	CSXT 805753	11/18/94	5 - 5 Gal	Yes	Yes
#5 (Lab #94-4774)	11/17/94	Albright Mine	CSXT 351214	11/05/94	1 - 5 Gal	-----	-----
#6 (Lab #94-4775)	11/17/94	Albright Mine	CSXT 831431	11/05/94	1 - 5 Gal	-----	-----
#7 (Lab #94-4819)	12/19/94	Albright Mine	CSXT 829386	11/27/94	4 - 5 Gal	Yes	-----
#8 (Lab #95-309)	Jan 95	Albright Mine	CSXT 348914	12/27/94	1 - 5 Gal	-----	-----
#9 (Lab #95-310)	Jan 95	Albright Mine	CSXT 803535	12/28/94	1 - 5 Gal	-----	-----
#10 (Lab #95-311)	Jan 95	Albright Mine	CSXT 806643	12/28/94	1 - 5 Gal	-----	-----

By-Product I.D. No.	Sample Date	Location	Rail Car Number	Ship Date	Sample Quantity	Samples Sent to Pitt	Samples Sent to Mill Ser.
Ebensburg Power Co. #1 (Lab #94-3982)	10/25/94	Ebensburg PA	-----	-----	1 - 5 Gal	-----	-----
(Bed Ash) #1a (Lab #94-3984)	10/25/94	Ebensburg PA	-----	-----	1 - 5 Gal	-----	-----
(Bag House Dust) #1b (Lab #94-3983)	10/25/94	Ebensburg PA	-----	-----	1 - 5 Gal	-----	-----
#2 (Lab #94-3981)	10/28/94	Ebensburg PA	-----	-----	2 - 5 Gal	Yes	Yes
#3 (Lab #94-4419)	11/18/94	Ebensburg PA	-----	-----	6 - 5 Gal	Yes	Yes
#4 (Lab #94-4778)	11/25/94	Ebensburg PA	-----	-----	6 - 5 Gal	Yes	Yes
#5 (Lab #95-009)	12/27/94	Ebensburg PA	-----	-----	6 - 5 Gal	Yes	-----
#6 (Lab #95-354)	2/9/95	Ebensburg PA	-----	-----	2 - 5 Gal	-----	-----
#7 (Lab #95-466)	2/14/95	Ebensburg PA	-----	-----	2 - 5 Gal	-----	------
#8 (Lab #95-467)	2/15/95	Ebensburg PA	-----	-----	2 - 5 Gal	-----	-----
#9 (Lab #95-468)	2/16/95	Ebensburg PA	-----	-----	2 - 5 Gal	-----	------
Tidd Station							
1 (Lab #94-4777)	9/21/94	Brilliant Ohio	-----	-----	2 - 5 Gal	-----	-----
2 (Lab #94-4776)	12/12/94	Brilliant Ohio	-----	-----	6 - 5 Gal	Yes	Yes
3 (Lab #94-4817)	12/15/94	Brilliant Ohio	-----	-----	2 - 5 Gal	-----	-----
4 (Lab #94-4818)	12/20/94	Brilliant Ohio	-----	-----	2 - 5 Gal	-----	-----
5 (Lab #95-007)	12/22/94	Brilliant Ohio	-----	-----	2 - 5 Gal	-----	-----
6 (Lab #95-008)	12/28/94	Brilliant Ohio	-----	-----	2 - 5 Gal	-----	-----
#7 (Lab #95-404)	2/1/95	Brilliant Ohio	-----	-----	2 - 5 Gal	-----	-----

By-Product I.D. No.	Sample Date	Location	Rail Car Number	Ship Date	Sample Quantity	Samples Sent to Pitt	Samples Sent to Mill Ser.
CONSOL #1 (Lab #94-4769)	11/23/94	Waynesburg Terminal	ACCX 1015	-----	5 - 5 Gal	Yes	Yes
#2 (Lab #94-4770)	11/21/94	Waynesburg Terminal	ACCX 1039	-----	2 - 5 Gal	-----	-----
#3 (Lab #94-4771)	11/22/94	Waynesburg Terminal	ACCX 1053	-----	2 - 5 Gal	-----	-----
#4 (Lab #94-4772)	11/22/94	Waynesburg Terminal	ACCX 1012	-----	2 - 5 Gal	-----	-----
#5 (Lab #95-106)	12/14/95	Waynesburg Terminal	ACCX 1021	-----	2 - 5 Gal	-----	-----
#6 (Lab #95-107)	12/16/94	Waynesburg Terminal	ACCX 1051	-----	2 - 5 Gal	-----	-----

APPENDIX C

BY-PRODUCT ANALYSES BY DLC

Dravo Lime Co. Research Center
Project # 5256 University of Pittsburgh
2nd Qtr. Report
February, 1995

Sample Analysis Report:
Ebensburg Power Co.
CFBC Ash

Sample ID	#1 Ash Silo	#1A Bed Ash	#1B Fly Ash	#2 Ash Silo	#4 Ash Silo
Sampling Date	10/25/94	10/25/94	10/25/94	10/28/94	11/25/94
Lab#	94-3982	94-3984	94-3983	94-3981	94-4778
Geo Chemical, %:					
CaO				10.15	
MgO				1.15	
SiO_2				48.47	
Fe_2O_3				6.76	
Al_2O_3				18.94	
CO_2				0.68	
Total Sulfur as S				2.22	
SO_3				4.99	
SO_2				0.44	
LOI @ 600 °C					
LOI @ 1100 °C				6.40	
Total of Elements Determined (calculated to oxide basis)				97.30	
Reactivity:					
Temperature Rise F°	17			17	6
Calc. Carb. Equiv., %$CaCO_3$	13.0			11.3	11.4
Available Lime Index, % CaO	3.4	2.1	2.1	3.4	3.7
pH (Soil)	12.42 @ 25 °C			12.42 @ 25 C	12.59 @ 24 C
Mixed Ratio(lbs/gal)	18			17	18
Physical Properties:					
Specific Gravity, g/cc	2.68			2.68	2.74
Bulk Density(Loose), lb/ft^3	63			56	49
Bulk Density(Tamped), lb/ft^3	70			63	57
Blaine Fineness, cm^2/g	7860			7270	9080
Passing 200 Mesh, %	42			49	61
Passing 325 Mesh, %	36			39	55

Sample Analysis Report:

CONSOL - Carney's Point
Spray Dryer Fly Ash

Sample ID	#1 Fly Ash	#2 Fly Ash	#3 Fly Ash	#4 Fly Ash
Sampling Date	11/23/94	11/21/94	11/22/94	11/22/94
Lab#	94-4769	94-4770	94-4771	94-4772
Geo Chemical, %:				
CaO	25.41			
MgO	0.70			
SiO_2	22.33			
Fe_2O_3	6.23			
Al_2O_3	11.40			
CO_2	3.58			
Total Sulfur as S	9.62			
SO_3	1.79			
SO_2	17.79			
LOI @ 600 °C	3.17			
LOI @ 1100 °C	14.68			
Total of Elements Determined (calculated to oxide basis)	100.33			
Reactivity:				
Temperature Rise F°	1	2	2	1
Calc. Carb. Equiv., %$CaCO_3$	42.5	42.1	42.2	42.8
Available Lime Index, % CaO	3.2	2.3	3.0	2.2
pH (Soil)	12.36 @ 26 °C	12.30 @ 23 °C	12.25 @ 23 °C	12.29 @ 24 °C
Mixed Ratio(lbs/gal)	13	13	13	13
Physical Properties:				
Specific Gravity, g/cc	2.40	2.40	2.42	2.42
Bulk Density(Loose), lb/ft^3	35	36	37	35
Bulk Density(Tamped), lb/ft^3	42	42	42	43
Blaine Fineness, cm^2/g	13190	12680	11510	11120
Passing 200 Mesh, %	96	99	98	92
Passing 325 Mesh, %	83	90	81	76

Dravo Lime Co. Research Center
Project # 5256 University of Pittsburgh
2nd Qtr. Report
February, 1995

Sample Analysis Report:

AES Thames River
CFBC Ash

Sample ID	#1 Fly Ash	#2 Fly Ash	#3 Fly Ash	#4 Fly Ash	#5 Fly Ash	#6 Fly Ash	#7 Fly Ash
Sampling Date	10/17/94	11/10/94	11/10/94	12/01/94	11/17/94	11/17/94	12/19/94
Lab#	94-3863	94-4209	94-4210	94-4773	94-4774	94-4775	94-4819
Geo Chemical, %:							
CaO		18.41		15.11			
MgO		0.60		0.62			
SiO_2		25.28		30.60			
Fe_2O_3		6.41		5.11			
Al_2O_3		14.41		17.43			
CO_2		1.64		1.32			
Total Sulfur as S		3.85		3.03			
SO_3		8.61		6.87			
SO_2		0.80		0.56			
LOI @ 600 °C							
LOI @ 1100 °C		21.61		20.06			
Total of Elements Determined (calculated to oxide basis)		96.13		96.36			
Reactivity:							
Temperature Rise F°	13	13	13	4	4	6	7
Calc. Carb. Equiv., %$CaCO_3$	17.2	20.3	20.4	15.4	24.6	18.3	25.1
Available Lime Index, % CaO	6.1	6.9	7.0	5.8	10.5	9.5	9.0
pH (Soil)	12.34 @ 25 °C	12.10 @ 26 °C	12.06 @ 26 °C	12.60 @ 24 °C	12.59 @ 24°C	12.57 @ 25 °C	12.55 @ 25 °C
Mixed Ratio(lbs/gal)	12	12	12	12	12	12	18
Physical Properties:							
Specific Gravity, g/cc	2.52	2.52	2.52	2.50	2.66	2.60	2.72
Bulk Density(Loose), lb/ft^3	37	35	41	38	38	38	38
Bulk Density(Tamped), lb/ft^3	44	40	46	46	47	46	45
Blaine Fineness, cm^2/g	5920	6390	6240	6620	6520	6390	7450
Passing 200 Mesh, %	85	92	94	94	97	90	96
Passing 325 Mesh, %	75	78	82	88	82	75	83

Dravo Lime Co. *Research Center*
Project # 5256 *University of Pittsburgh*
2nd Qtr. Report
February, 1995

Sample Analysis Report:

Tidd-AEP

PFBC Cyclone Ash

Sample ID	# 1 Cyclone Ash	# 2 Cyclone Ash	# 3 Cyclone Ash	# 4 Cyclone Ash
Sampling Date	09/21/94	12/12/94	12/15/94	12/20/94
Lab#	94-4777	94-4776	94-4817	94-4818
Geo Chemical, %:				
CaO		22.13		
MgO		14.38		
SiO_2		19.93		
Fe_2O_3		9.02		
Al_2O_3		7.75		
CO_2		12.57		
Total Sulfur as S		4.59		
SO_3		10.60		
SO_2		0.69		
LOI @ 600 °C				
LOI @ 1100 °C		13.54		
Total of Elements Determined (calculated to oxide basis)		98.04		
Reactivity:				
Temperature Rise F°	2	2	11	5
Calc. Carb. Equiv., %$CaCO_3$	53.8	53.4	45.9	52.0
Available Lime Index, % CaO	0.5	1.0	1.1	1.0
pH (Soil)	10.02 @ 23 C	11.92 @ 25 C	11.03 @ 22 C	11.91 @ 22 C
Mixed Ratio(lbs/gal)	25	25	20	20
Physical Properties:				
Specific Gravity, g/cc	2.85	2.88	2.87	2.88
Bulk Density(Loose), lb/ft^3	58	64	60	60
Bulk Density(Tamped), lb/ft^3	67	70	72	70
Blaine Fineness, cm^2/g	6150	5610	5580	5480
Passing 200 Mesh, %	91	92	81	89
Passing 325 Mesh, %	85	85	73	83

APPENDIX D

ANALYTICAL REQUEST FORMS USED BY MSI

MILL SERVICE, INC. - YUKON PLANT
ANALYTICAL REQUEST FORM[1]

Project: MSI-METC
Sample ID:________________________
Matrix: Waste
Quantity:_________________________

PARAMETER	ANALYTICAL METHOD[2]	DESIRED DETECTION LEVEL(mg/kg)
As	6010A	≤20
Ba	6010A	≤10
Cd	6010A	≤2
Cr	6010A	≤2
Pb	6010A	≤7
Hg	7470	≤0.4
Se	6010A	≤20
Ag	6010A	≤2
Cu	6010A	≤10
Ni	6010A	≤10
Zn	6010A	≤10

Comments: ____

Send Results To: Carl F. Bender, P.E.
Mill Service, Inc.
1815 Washington Road
Pittsburgh, PA 15241

[1]This form to be used for waste samples sent to Antech for analysis.

[2]All methods per SW-846.

MILL SERVICE, INC. - YUKON PLANT
ANALYTICAL REQUEST FORM[1]

Project: MSI-METC
Sample ID:______________________
Matrix: TCLP Extract
Quantity:______________________

PARAMETER	ANALYTICAL METHOD[2]	DETECTION LEVEL(mg/l)
As	6010A	≤0.5
Ba	6010A	≤5.0
Cd	6010A	≤0.1
Cr	6010A	≤0.1
Pb	6010A	≤0.1
Hg	7470	≤0.02
Se	6010A	≤0.1
Ag	6010A	≤0.1
Cu	6010A	≤1.0
Ni	6010A	≤1.0
Zn	6010A	≤1.0

Comments: ______________________

Send Results To: Carl F. Bender, P.E.
Mill Service, Inc.
1815 Washington Road
Pittsburgh, PA 15241

[1]This form to be used for TCLP Extracts sent to Antech for analysis.

[2]All methods per SW-846.

MILL SERVICE, INC. - YUKON PLANT
ANALYTICAL REQUEST FORM[1]

Project: MSI-METC
Sample ID:________________
Matrix: Waste
Quantity:________________

PARAMETER	ANALYTICAL METHOD[2]	DESIRED DETECTION LEVEL(mg/l)
Sb	7041	≤20
Be	7091	≤0.20
Tl	7841	≤1.0
V	7911	≤4.0

Comments: ____

____

____

____

Send Results To: Carl F. Bender, P.E.
Mill Service, Inc.
1815 Washington Road
Pittsburgh, PA 15241

[1]This form to be used for waste samples sent to Pitt for analysis.

[2]All methods per SW-846.

MILL SERVICE, INC. - YUKON PLANT
ANALYTICAL REQUEST FORM[1]

Project: MSI-METC
Sample ID:____________________
Matrix: TCLP Extract
Quantity:____________________

PARAMETER	ANALYTICAL METHOD[2]	DETECTION LEVEL(mg/l)
Sb	7041	≤2.0
Be	7091	≤0.010
Tl	7841	≤0.070
V	7911	≤0.20

Comments: ____

Send Results To: Carl F. Bender, P.E.
Mill Service, Inc.
1815 Washington Road
Pittsburgh, PA 15241

[1]This form to be used for TCLP Extracts sent to Pitt for analysis.

[2]All methods per SW-846.

APPENDIX E

ANALYSES BY MSI

BY-PRODUCT TOTAL METALS DATA

Parameter	Units	AES #4	CONSOL #1	EPC #3	Tidd #2
Antimony (Sb)	mg/kg				
Arsenic (As)	mg/kg	21	41	95	140
Barium (Ba)	mg/kg	170	97	160	150
Beryllium (Be)	mg/kg				
Cadmium (Cd)	mg/kg	2.2	6.6	10	4.8
Chromium (Cr)	mg/kg	52	29	50	15
Copper (Cu)	mg/kg	30	20	35	17
Lead (Pb)	mg/kg	4.9	3.0	3.6	4.6
Mercury (Hg)	mg/kg	0.66	0.55	1.1	<0.10
Nickel (Ni)	mg/kg	280	23	21	12
Selenium (Se)	mg/kg	1.4	<0.2	<0.2	<0.2
Silver (Ag)	mg/kg	<2.0	<2.0	<2.0	<2.0
Thallium (Th)	mg/kg				
Vanadium (V)	mg/kg				
Zinc (Zn)	mg/kg	37	34	52	78

BY-PRODUCT TCLP DATA

Parameter	Units	AES #4	CONSOL #1	EPC #3	Tidd #2
Antimony (Sb)	mg/l				
Arsenic (As)	mg/l	<0.1	<0.1	0.89	<0.1
Barium (Ba)	mg/l	<5.0	<5.0	<5.0	<5.0
Beryllium (Be)	mg/l				
Cadmium (Cd)	mg/l	<0.1	<0.1	<0.1	<0.1
Chromium (Cr)	mg/l	<0.1	<0.1	<0.1	<0.1
Copper (Cu)	mg/l	<1.0	<1.0	<1.0	<1.0
Lead (Pb)	mg/l	<0.1	<0.1	<0.1	<0.1
Mercury (Hg)	mg/l	<0.01	<0.01	<0.01	<0.01
Nickel (Ni)	mg/l	<0.1	<0.1	<0.1	<0.1
Selenium (Se)	mg/l	<0.1	<0.1	<0.1	<0.1
Silver (Ag)	mg/l	<0.1	<0.1	<0.1	<0.1
Thallium (Th)	mg/l				
Vanadium (V)	mg/l				
Zinc (Zn)	mg/l	<1.0	<1.0	<1.0	<1.0
Extraction Fluid		2	2	2	2
Initial pH	SU	12.85	12.71	12.67	11.41
Final pH	SU	9.53	7.02	11.49	9.86

WASTE TOTAL METALS DATA

Parameter	Units	SLUDGE[1]	SOIL[2]	SOIL[3]	SOIL[4]	DUST[5]	DUST[6]
Antimony (Sb)	mg/kg						
Arsenic (As)	mg/kg	<20	<20	<20		<20	84
Barium (Ba)	mg/kg	13	130	130		34	550
Beryllium (Be)	mg/kg						
Cadmium (Cd)	mg/kg	3.0	4.8	5.4		55	630
Chromium (Cr)	mg/kg	12	59	22		260	130
Copper (Cu)	mg/kg	30	210	260		57	1300
Lead (Pb)	mg/kg	3000	1200	5000		1400	5700
Mercury (Hg)	mg/kg	0.14	0.20	3.2		0.30	4.7
Nickel (Ni)	mg/kg	15	19	26		130	96
Selenium (Se)	mg/kg	<0.2	<0.2	<0.2		<0.2	85
Silver (Ag)	mg/kg	<2.0	3.6	<2.0		<2.0	6.9
Thallium (Th)	mg/kg						
Vanadium (V)	mg/kg						
Zinc (Zn)	mg/kg	30	580	660		41000	23000

Notes: 1 - Industrial Wastewater Treatment Residue From A Battery Manufacturing Plant
2 - Contaminated Soil From A Remediation Project Conducted At A Munitions Depot
3 - Contaminated Soil From A Remediation Project Conducted At An Abandoned Multi-Use Industrial Site
4 - Contaminated Soil From A Remediation Project Conducted At A Former Sewage Treatment Plant
5 - Air Pollution Control Dust From Basic Oxygen Furnace Steel Production
6 - Air Pollution Control Ash From Municipal Waste Incineration

WASTE TCLP DATA

Parameter	Units	SLUDGE[1]	SOIL[2]	SOIL[3]	SOIL[4]	DUST[5]	DUST[6]
Antimony (Sb)	mg/l						
Arsenic (As)	mg/l	<0.1	<0.1	<0.1		<0.1	0.2
Barium (Ba)	mg/l	<5	<5	<5		<5	<5
Beryllium (Be)	mg/l						
Cadmium (Cd)	mg/l	0.19	<0.1	<0.1		<0.1	<0.1
Chromium (Cr)	mg/l	<0.1	<0.1	<0.1		<0.1	<0.1
Copper (Cu)	mg/l	1.3	1.6	<1		<1	<1
Lead (Pb)	mg/l	20	26	80	7.8	14	20
Mercury (Hg)	mg/l	<0.01	<0.01	<0.01		<0.01	<0.01
Nickel (Ni)	mg/l	0.78	0.041	0.23		<0.01	<0.1
Selenium (Se)	mg/l	<0.1	<0.1	<0.1		<0.1	<0.1
Silver (Ag)	mg/l	<0.1	<0.1	<0.1		<0.1	<0.1
Thallium (Th)	mg/l						
Vanadium (V)	mg/l						
Zinc (Zn)	mg/l	2.9	8.2	17		4.4	2.1
Extraction Fluid		1	1	1	1	2	2
Initial pH	SU	9.19	7.37	8.83	8.21	12.94	6.55
Final pH	SU	4.86	5.69	5.16	4.77	12.60	5.24

Notes: 1 - Industrial Wastewater Treatment Residue From A Battery Manufacturing Plant
2 - Contaminated Soil From A Remediation Project Conducted At A Munitions Depot
3 - Contaminated Soil From A Remediation Project Conducted At An Abandoned Multi-Use Industrial Site
4 - Contaminated Soil From A Remediation Project Conducted At A Former Sewage Treatment Plant
5 - Air Pollution Control Dust From Basic Oxygen Furnace Steel Production
6 - Air Pollution Control Ash From Municipal Waste Incineration

APPENDIX F

ANALYSES BY PITT

Table 1: By-Product Analysis

DOE/METC Project
" Treatment of Metal Laden Hazardous Waste with Advanced Clean Coal Technology By-Products"

Atomic Adsorption Analysis

By-Product Source	Sample	Method	Cd (mg/L)	Cr (mg/L)	Cu (mg/L)	Pb (mg/L)	Ni (mg/L)	Zn (mg/L)
Consol	1	ASTM	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
		TCLP						
Tidd	2	ASTM	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
		TCLP						
Ebensbug	2	ASTM	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
		TCLP	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
	3	ASTM	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
		TCLP						
	4	ASTM						
		TCLP	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	0.127
	5	ASTM						
		TCLP	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	0.099
AES Thames River	2	ASTM	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
		TCLP	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
	4	ASTM	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
		TCLP						
	7	ASTM						
		TCLP	< 0.05	< 0.50	< 0.20	< 1.00	<0.30	<0.05
Lower Calibration Limits			0.05	0.50	0.20	1.00	0.30	0.05
Method Detection Limits			0.01	0.04	0.02	0.10	0.10	0.02
Maximum Contaminant Level			0.01	0.05	1.00	0.05		5.00
Hazardous Concentration			1.00	5.00	100.00	5.00		500.00
BDAT Maximum*			0.19	0.86		0.37	5.10	5.30

* see 40 CFR 268

APPENDIX G

BY-PRODUCT REVIEW

CHARACTERIZATION OF ADVANCED CLEAN COAL TECHNOLOGY BY-PRODUCTS

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ABSTRACT

The 1990 amendments to the Clean Air Act have spurred the development of Clean Coal Technology (CCT) processes, most of which produce a dry, solid by-product material consisting of excess sorbent, reaction products containing sulfates and sulfites, and coal fly ash. Presently, most of the dry combustion/desulfurization by-product materials are treated as solid wastes and must be landfilled. It is, therefore, highly desirable to find beneficial reuses for these materials provided the environmental impacts are minimal and socially acceptable. One potential opportunity for utilization of the mass quantities of CCT by-products that are being produced is the stabilization and solidification of metal-laden hazardous wastes. In order to explore the feasibility of the utilization of dry combustion/desulfurization by-products for the stabilization and solidification of metal-laden hazardous wastes, the chemical, mineralogical, physical, and leaching properties of the by-products need to be well defined so as to enable further study of their interactions with toxic metals. The objective of this paper is to characterize these selected critical properties of typical advanced CCT by-products that are representative of the actual by-products that will be used in the "Treatment of Metal-Laden Hazardous Wastes with Advanced Clean Coal Technology By-Products" research project. A literature review of previous reports of by-product characterization obtained from various clean coal technologies has yielded the resulting representative characterization of the chemical, mineralogical, physical, and leaching properties described in the text of this paper. A survey of descriptions of the types of power plants producing the four by-products used in this study provides insights into the origin of these properties and variations in them. The information presented here will hopefully lead to the eventual identification and commercial application of beneficial uses of advanced clean coal technology by-products.

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INTRODUCTION

The Clean Coal Technology (CCT) Program is a cooperative effort, cofunded by government and industry, to demonstrate a new generation of innovative coal processes, which are environmentally cleaner and more efficient than conventional coal-burning processes.[1] In dry CCT systems, a calcium-based sorbent (usually slaked lime, limestone, or dolomite) is injected directly into a furnace, ductwork, precipitator, or scrubber vessel that produces powdered or granular by-products, as opposed to the slurries associated with traditional wet scrubber systems. The specific composition of a particular type of by-product may vary widely depending upon the CCT process employed, the coal and sorbent composition, and the plant operating conditions. Since the chemical, physical, and engineering properties of dry CCT by-products are directly related to their mineralogy, it is essential to accurately determine the mineralogical composition of these wastes if safe and economical uses are to be defined. Vast quantities of dry CCT wastes may be produced in the near future and it is important that beneficial uses be developed to reduce landfill demands.[2]

In dry sulfur sorption systems the sorbent is injected directly into the furnace, into the ductwork after the furnace at lower temperature, or into a spray dryer vessel. All these processes produce a by-product which is removed in the particulate control equipment. Dry by-products from lime or limestone injected into the furnace, such as in FBC systems, have neutralizing, sorptive, and cementitious properties that make them particularly interesting as potential reagents for hazardous waste stabilization because of their high free quicklime (CaO) and anhydrous calcium sulfate ($CaSO_4$) contents.

The objective of this paper is to review the chemical, mineralogical, physical, and leaching properties that are typical to CCT by-products in order to determine their usefulness in the treatment of metal-laden hazardous wastes. Four advanced clean coal technology combustion/desulfurization by-products have been identified for use in laboratory studies and for potential use in field studies of the treatment of metal-laden solid hazardous wastes. The sources of the by-products identified for this study are described below.

SOURCES

Residue from a Coal-Fired Circulating Fluid Bed Combustor (CFBC), supplied by Anker Energy Corporation. This material is produced by the cogeneration project of Applied Energy Service at its Thames River Plant near Uncasville, Connecticut. Anker Energy Corporation supplies the coal used in the plant and must backhaul the residue to its mines in West Virginia. Some or all of the approximately 100,000 tons/year of this by-product could be easily diverted to hazardous waste treatment plants along the general rail route from Connecticut to West Virginia. The residue is estimated to contain 45% limestone equivalent, 28% ash and 27% $CaSO_3$/$CaSO_4$. It is relatively coarse material, as it contains both bottom and fly ash from the boiler.[3]

Dry Scrubber Residue, supplied by CONSOL, Inc. from a Joy Niro Spray Dryer. This material is produced by the cogeneration project of Chambers Cogeneration Limited Partnership, operated by U.S. Operating Services Company on the grounds of DuPont's Chambers Works in New Jersey. CONSOL, Inc. supplies the coal used in the plant and has agreed to backhaul the residue to its mines in western Pennsylvania and West Virginia. Some or all of the approximately 100,000 tons/year of this by-product could be easily diverted to hazardous waste treatment plants along the general rail route from New Jersey to western Pennsylvania and West Virginia. The residue contains 45% fly ash, 36% $CaSO_3/CaSO_4$, 10% $Ca(OH)_2$, 2% $CaCO_3$, and 7% other inert material. It is comprised of agglomerates of fine materials, formed in the scrubber.[3]

Residue from a Coal-Waste-Fired CFBC operated by the Ebensburg Power Company. Approximately 200,000 tons/year of this material is produced in an operating unit at Ebensburg, Pennsylvania. Currently it is being trucked back to the mines from which the coal wastes are derived. Some or all of this by-product could be diverted to nearby sites for beneficial use if they could be identified. The residue contains 82% ash, 12.5% limestone equivalent and 5.5% $CaSO_3/CaSO_4$. It is relatively coarse material, as it contains both bottom and fly ash from the boiler.[3]

Residue from a Coal-Fired Pressurized Fluid Bed Combustor (PFBC), supplied by the Tidd Station of Ohio Power Company, a subsidiary of American Electric Power Corporation, at Brilliant, OH. This demonstration facility was constructed and is operated in cooperation with the U.S. Department of Energy in Round 1 of the Clean Coal Technology Program. This large prototype facility is the first full-scale demonstration of the pressurized fluidized bed combustion (PFBC) process in the U.S. The Babcock & Wilcox design unit has a gross electrical output of 74 MW. Pittsburgh #8 coal is burned with dolomite as the sorbent, rather than lime or limestone, at a calcium to sulfur molar ratio of 1.6:1. Sulfur removal efficiencies of 90% or better are anticipated along with NO_x emissions that meet federal standards. By operating at high pressure, little of the dolomite in the residue is in the oxide form, most is present as carbonate. Three flue gas desulfurization (FGD) by-products, totaling approximately 22 tons per hour, are produced in the PFBC process: bed ash, cyclone ash, and precipitator ash.[5,6] Thus, the residue may be obtained as bottom ash, fly ash, or a mixture. The dolomitic character of the sorbent yields a residue that is lower in pH than that produced from lime-based sorbents. This characteristic is particularly useful in stabilizing arsenic-laden waste solids.[3] According to Dravo Lime, the chemical composition of the residue is 50-60% equivalent $CaCO_3$ and 1-2% available (free or uncombined) CaO.

CLEAN COAL TECHNOLOGY PROCESSES

Fluidized Bed Combustors

Fluidized bed combustion (FBC) is a process of burning crushed coal in a bed of limestone particles held in suspension by the upward flow of combustion air entering a chamber through a perforated air distribution grid below the fluidized bed. Lime is specifically calcium oxide (CaO) and usually contains varying amounts of other alkaline products in small amounts such as sodium and magnesium oxides as well as calcium carbonate. Commercial chemical grade hydrated lime contains over 92% calcium hydroxide or calcium oxide.[7] Crushed limestone is first placed in the bed on the air distribution grid. The bed is then fluidized by injecting air through the grid to form an expanded, suspended mass closely resembling a boiling liquid, hence the name "fluidized." Oil burners are used to heat the bed material to the coal ignition temperature, and then coal feed is started.[7] During operation, coal and limestone are fed continuously into the bed. The tumbling motion of the coal enhances the burning process. Combustion temperatures are held to around 1,400 to 1,600 °F, or almost half the temperature of a conventional boiler.[1]

As the coal burns, sulfur is released as sulfur dioxide. The limestone reacts with the sulfur dioxide and prevents the sulfur dioxide from escaping into the atmosphere. The chemical process is as follows:

Limestone	(Heat)	Calcium Oxide		Carbon Dioxide
(Non-porous Solid)	→	(Porous Solid)	+	(Gas)
$CaCO_3$		CaO		CO_2

Calcium Oxide		Sulfur Dioxide		Oxygen		Calcium Sulfate
(Porous Solid)	+	(Gas)	+	(Gas)	→	(Like Plaster)
CaO		SO_2		$1/2O_2$		$CaSO_4$

The limestone acts like a chemical "sponge" to capture the sulfur before it can escape the boiler. More than 90% of the sulfur released from coal can be caught in this manner. The sulfur-laden limestone and the ash from the coal form a dry waste product. Larger particles of coal ash and spent limestone are drained from the bottom of the bed. The smaller ash and spent limestone particles, or "fly ash", are carried out of the boiler and captured with dust collectors. These dry residues are potentially usable, among other things, in stabilizing hazardous wastes and as cement additives.

There are three types of fluidized bed combustion being demonstrated in the Clean Coal Technology Program: atmospheric FBC (AFBC), circulating FBC (CFBC), and pressurized FBC (PFBC). Both AFBC and CFBC operate at normal atmospheric pressures; whereas PFBC operates at pressures inside the boiler that are 6 to 16 times higher than normal atmospheric pressure. The fundamental distinguishing feature between AFBC and CFBC is the velocity of the air through the unit. The AFBC has lower fluidization velocities, about 5-12 ft/sec, while CFBCs have velocities as high as 30 ft/sec.[8]

The two sources from FBC processes examined in this study are residues from circulating FBC and pressurized FBC systems. In circulating FBC all residues collected by the cyclone are recycled as shown in Figure 1. There are two main sources of pressurized FBC residues, either from bed-offtake or cyclone discharge, as shown in Figure 2.

FIGURE 1: Circulating FBC Process Showing Residue Sources

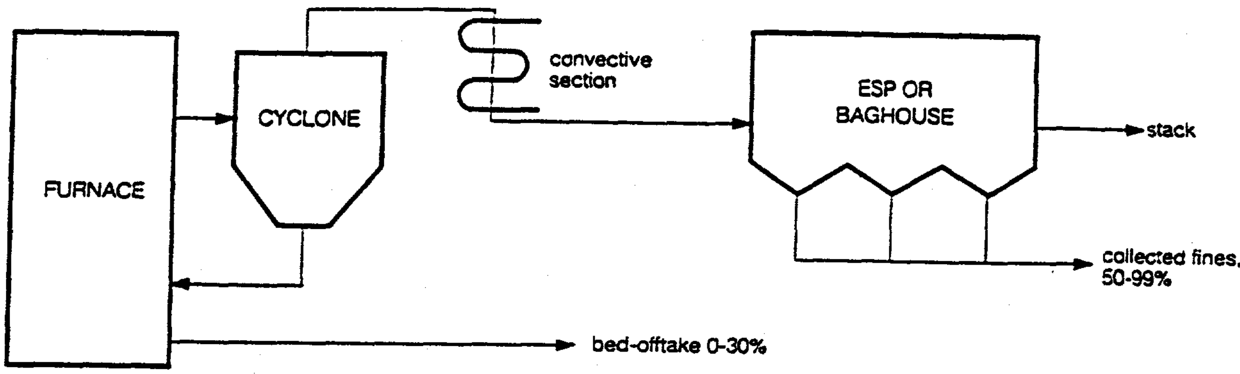


FIGURE 2: Pressurized FBC Process Showing Residue Sources

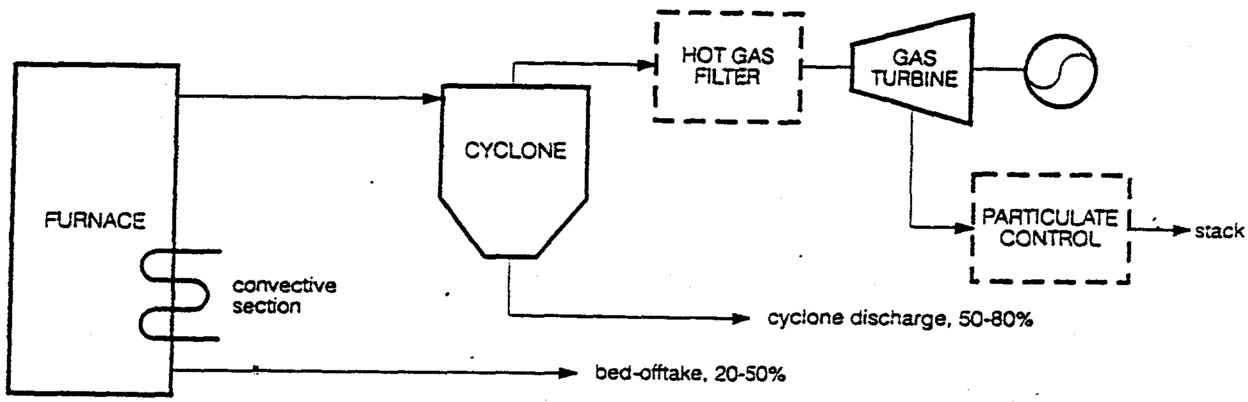
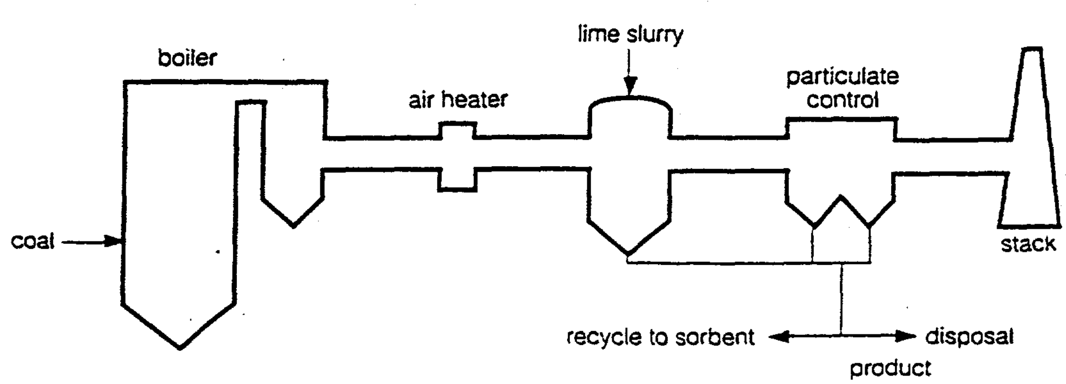


FIGURE 3: The Spray Dry Scrubber Process



Spray Dry Scrubbers

This technology evolved as an alternative to wet scrubbers and was first used commercially on a coal-fired power station in the U.S. in 1980. Spray dry scrubber processes involve gas/liquid reactions. In spray dry scrubbers an alkaline reagent slurry (usually lime in water) is injected in a finely atomized form into the reaction vessel, which is why these devices are also known as spray dryers. This slurry of alkaline material is mixed with the flue gases at air preheater outlet temperatures. The flue gases are humidified by finely dispersed droplets. The moisture associated with the entering droplets evaporates in hot gas, drying as it reacts with the SO_2 in the flue gases. As the slurry or solution is evaporated, liquid-phase salts are precipitated and the remaining solids are dried, generally to less than a few percent free moisture. The solids and fly ash, entrained in the flue gases, are carried out from the spray dry scrubber to a particulate collection device, either an electrostatic precipitator (ESP) or fabric filter (baghouse), thus leaving only dry particles for collection as waste. Slaked lime is generally used as a sorbent, although sodium carbonate is used in a few installations. Spray dry scrubbers are designed to achieve 70-95% SO_2 removal but the process has the potential to remove up to 98% of SO_2. The by-product is a dry mixture of calcium sulphite, calcium sulphate, fly ash, and unreacted lime.[9] Figure 3 above shows a spray dry scrubber process.

BY-PRODUCT CHARACTERIZATION

Coal-fired power generation facilities produce high volumes of solid by-products. Fly ash comprises a high percentage of these by-products. The utilization of coal fly ash has significant benefits and expanding fly ash utilization in an environmentally responsible manner is a major objective of this CCT by-product research. Information is needed to determine the by-product type most appropriate for treating metal-laden hazardous wastes. This information includes chemical, leaching, and mineralogical characteristics and reactions responsible for desired engineering properties.

It is well known that fly ash is an inherntly variable material due to differences in the inorganic chemical composition of the source coal, the coal preparation, the combustion conditions, and ash collection and handling methods at individual facilities. The variable nature of coal, combined with conversion process variables and ash collection options results in materials exhibiting a wide range of chemical, physical, and mineralogical characteristics. Although the by-product characteristics are unique, they are predictable, within a range, for any given CCT process.[10] The chemical, physical, and mineralogical properties are characterized below, as well as a determination of the leaching characteristics.

Chemical Properties

Chemical analysis reveals information about the bulk chemical composition of a material through the application of accepted mehtods of analysis, such as atomic absorption (AA) and inductively coupled plasma (ICP).

The combustion of coal and the subsequent dry pollution control equipment generate a material called "fly ash". The chemical composition of coal fly ash may vary widely because of variation in coal composition, combustion conditions, and ash collection systems. Most fly ashes, however, contain a substantial amount of SiO_2 and Al_2O_3. The University of North Dakota's Energy & Environmental Research Center's Coal Ash Properties Database (CAPD) shows bituminous coal ashes ranging from 24-65 % SiO_2 and from 12-35 % Al_2O_3. These types of ashes also generally have low levels of CaO, but are reactive with calcium hydroxide and are termed "pozzolans." The lime-pozzolan reaction forms a low-strength cement. Ashes from low-rank coals, subituminous and lignite, generally have a higher CaO content with enough CaO free to react with silica, forming a cement. These types of ashes are generally considered cementitious. The CAPD shows a range of 17-65% SiO_2, 10-25 % Al_2O_3, and 1-31% CaO for these coal ashes. Other constituents such as alkalies or iron may alter the cementitious or pozzolanic reactions. The bulk chemistry of the coal ash and the wastes to be stabilized and solidified must be compatible for the beneficial reactions to occur.[11]

The American Society for Testing and Materials (ASTM) has created specifications for useful coal ashes. An "F Ash" is an ash with a total quantity of pozzolans, i.e., silicon, aluminum and iron oxides equaling or exceeding 70 % by weight of the total ash mass. Some typical examples of "F Ash" are given in Table 1[7] and the range of oxide compounds specific for "F Ash" is given in Table 2.[12]

TABLE 1: Typical Percent Specifications For Examples of "F Ash"

Example #	CaO	SiO_2	Al_2O_3	MgO	Na_2O	K_2O	Fe_2O_3	SO_3	LOI
1	6.69	55.1	12.1	1.61	1.73	1.24	5.16	0.52	0.62
2	2.2	48.3	19.4	0.73	2.12	-	11.8	0.56	2.33
3	1.53	44.1	19.6	0.7	0.33	2.39	21.5	0.77	4.93
4	7.48	48.9	22.8	1.54	2.86	0.67	6.09	0.30	0.54

LOI = Lost On Ignition (organic matter volatized during test)

TABLE 2: Total Oxide Compound Analysis of Typical Fly Ash

Oxide Compound	Range % Composition of Fly Ash
Silicon Dioxide (SiO_2)	30-60
Aluminum Oxide (Al_2O_3)	18-32
Iron Oxide (Fe_2O_3)	3-11
Calcium Oxide (CaO)	1-28
Magnesium Oxide (MgO)	0.5-7.0
Sulfur Trioxide (SO_3)	0-3

The exact composition of sulfur sorption by-products is dependent upon the specific process, coal and sorbent compositions, and plant operating conditions. However, in general these by-products consist of a mixture of conventional ash, unspent sorbent (usually lime or dolomite), and the primary reaction product which is anhydrite ($CaSO_4$) or calcium sulfite ($CaSO_3 \cdot 1/2H_2O$). Due to their lime contents, dry sulfur sorption by-products are highly alkaline with calcium carbonate equivalents (CCE) in the range of 40-60% and free or available lime contents of up to 25% CaO. These properties may reflect desirable sorption characteristics for use in waste stabilization.[5]

Mineralogical Properties

Of equal importance to the bulk chemistry of the coal ash is the mineralogy. Chemical analysis alone reveals only composition, not the structural arrangment (mineralogy). While the bulk chemistry of the coal ash indicates which elements are present and in what quantities, the mineralogy will indicate how those elements have arranged themselves into crystalline structures or minerals. Thus, mineralogical characterization provides information on the structure and assemblage of atoms (crystallinity) in material. Mineralogical characterization is typically carried out using x-ray diffraction (XRD) and/or computer-controlled scanning electron microscopy (CCSEM) with electron microprobe analysis (EMPA).[10]

Bituminous coal ashes tend to have relatively few minerals forming in them; quartz (SiO_2) and mullite ($Al_6Si_2O_{13}$) are the dominant ones. Other minerals found in the bituminous coal ashes are hematite (FeO_3) and spinels ($MgAl_2O_4$). The mineralogy found in low-rank coals often include quartz, mullite, anhydrite ($CaSO_4$), melilite ($NaCaAlSi_2O_7$), hematite, merwinite ($Ca_3Mg[SiO_4]_2$), lime (CaO), and periclase (MgO). These minerals often only constitute 10-40% of the coal ash and are generally non-reactive.

The remainder of the coal ash is usually a glassy or amorphous phase of variable composition. It is the glass-phase that accounts for the pozzolanic and cementitious properties of these ashes.

The lime (CaO) found in some of the ashes is the exception, where it can be free to react with the silica, forming a cement when it comes into contact with water. CaO can also be incorporated into the glassy phases where it can be detected by several different analytical techniques.

The mineral content of the coal fly ashes should be considered as part of the overall material properties when a coal fly ash is considered for hazardous waste stabilization and solidification,[11] because most properties of dry sulfur sorption by-products are directly related to their mineralogical composition. The exact composition is an outcome of the injection technology, the coal burned, and the type of sorbent; but, in general, the minerals in ash include reaction by-products (calcium sulfate, calcium sulfite, calcium carbonate, magnesium oxide), unreacted sorbent (lime, hydrated lime, dolomite) and fly ash. Tables 3 and 4 give the typical operating parameters of a 20 MW FBC plant and an example of the mineralogical composition of the FBC ash from the Tennessee Valley Authority's Shawnee Pilot Plant in Kentucky, respectively.[13] Table 5 gives the mineralogical composition of typical spray dryer and PFBC by-products.[5]

TABLE 3: Typical Operating Parameters of a 20-MW FBC Pilot Plant

Calcium-to-Sulfur Ratio	2.4
Sulfur Retention	90%
Recycle Ratio	2.0-2.5
Combustion Efficiency	98%
Bed Depth	4 ft.
Bed Temperature	1530°F
Superficial Velocity	8 ft/sec

TABLE 4: Typical Analysis of the Waste Streams from TVA's 20-MW Pilot Plant

Waste Stream	$CaSO_4$	CaO	$CaCO_3$	Carbon	Non-Carbonate	Other Ash	Total
Spent Bed %	57.2	28.2	-	-	85.5	14.2	100
Char %	36.5	26.2	4.4	11.3	78.4	21.6	100
FBC Fly Ash	24.6	13.3	4.6	7.6	50.1	49.9	100

TABLE 5: Mineralogical Composition of Typical Dry CCT By-Products (wt %)

Sample	$CaSO_4$	CaMg $(CO_3)_2$	CaO	Ca $(OH)_2$	$CaCO_3$	$CaSO_3$ $1/2H_2O$	MgO	Fly Ash	Total
Spry Dryer	ND	ND	ND	30	17	30	ND	21	98
PFBC Bed Ash	36	ND	3	ND	27	ND	27	10	103
PFBC Cyclone Ash	22	23	ND	ND	11	ND	13	32	101

ND = Not Detected

These typical mineralogical results show that scrubber residues from a spray dryer consist primarily of $Ca(OH)_2$ (portlandite) and $CaSO_3 \cdot 1/2H_2O$ (calcium sulfite hemihydrate). This phase is indicative of low flue gas reaction temperatures in the range of 150-200°C. Bed ash from the PFBC facility is enriched with $CaSO_4$, $CaCO_3$ and MgO (periclase), which is derived from calcination of the dolomite [$CaMg(CO_3)_2$] sorbent; whereas cyclone material contains mostly $CaMg(CO_3)_2$ and $CaSO_4$ and contains less MgO. The dry sulfur sorption material described here contained 10-32% fly ash arising from coal combustion. Chemical analyses of coal fly ash residues from the by-products are dominated by Al, Fe, and Si. This chemistry is consistent with fly ash mineralogy.

Physical Properties

Physical characterization reveals information relevant to the utilization of ash as an engineering material. The methods used for the tests applied to materials are rigidly uniform and have been carefully detailed in the protocols of the American Society for Testing and Materials (ASTM).

The bulk density of coal ash is important when a fly ash is considered for a stabilization and solidification application. Bulk density, specific gravity, and moisture content are properties used in the stabilization and solidification process to calculate porosity, which is of prime importance for the entrapment of contaminated particles. Fineness of a coal ash is an important physical property, with the finer ashes being more desirable because they tend to decrease the porosity of the solidified wastes. Fineness is a difficult property to measure directly, however, therefore specific surface area measurements are used instead, with higher surface areas indicating finer particles. The fineness of the coal ash affects the development of the cured product in that the finer the pozzolanic particles are, the stronger the end product is.[11]

Some typical physical properties of representative dry sulfur sorption by-products are given in Table 6.[6,14]

TABLE 6: Physical Properties of Selected Dry Sulfur Sorption By-Products

Sample	No. Samples	pH	CCE $CaCO_3$ %	Surface Area m^2/g	Particle Density g/cm^3	Bulk Density g/cm^3	Temperature Reactivity °C/20min
FBC Bed Ash	1	12.39	39.5	–	–	–	–
FBC Cyclone Ash	1	12.48	39.2	–	–	–	–
Spray Dyer	5	12.3	65.2	13.5	2.39	.59	1
PFBC Bed Ash	7	11.9	66.0	0.9	2.92	1.29	<1
PFBC Cyclone Ash	7	9.8	61.9	2.8	2.76	1.29	<1

Table 6 shows that the sulfur sorption by-products have calcium carbonate equivalents (CCE) ranging from 39.2-66.0 % as percent $CaCO_3$. The dry sulfur sorption by-product from the spray dryer has a relatively high surface area (13.5 m^2/g) and is found to pass a 100 mesh sieve (i.e. like fly ash).[6]

Leaching Properties

Leaching behavior, not always thought of as a component of chemical characterization, provides information on what materials may be liberated when a solid comes in contact with a liquid. Mineralogical characterization of the leached solids can also provide scientific insights concerning secondary phase formations and interactions within the material affecting the final leachate.[10]

When a waste is exposed to water a rate of dissolution can be measured, this process is called leaching. The contaminated water that passes through the waste is the leachate and the capacity of the waste material to leach is called its leachability. Leaching is a rate phenomenon and is of interest, environmentally, as the rate at which hazardous or other undesirable constituents are removed from the waste and passed into the environment via the leachate. This rate is usually measured and expressed, however, in terms of concentration of the constituents in the leachate.[15] Leaching tests are often used to evaluate the availability and/or mobility of various constituents in wastes, including coal ash, which is frequently considered a waste for regulatory purposes.[11]

The Toxicity Characteristic Leaching Procedure (TCLP) is the federally mandated EPA regulatory procedure for determination of hazardousness. The TCLP leachate must be analyzed for an extensive list of organic constituents and trace elements to determine the hazardousness of a particular material or waste.[11] Table 7 gives a comparison of water and acid TCLP leachate from a Pyporpower, 300,000 lb per hour CFBC rated at 28 MW and operated by General Motors in Pontiac Michigan; a Babcock & Wilcox designed PFBC called the Tidd Plant in Brilliant Ohio, which has a gross electrical output of 74 MW and produces both cyclone and bed ash; and a Joy Environmental spray dryer designed for a gas flow of 82,000 atmosphere cubic feet per minute operated by the Ohio State University Power Plant at Columbus, Ohio.[5]

TABLE 7
Comparison of Water and Acid TCLP Leachates
From Representative Dry Sulfur Sorption By-Products

All results given in mg/L

Sample		CFBC	PFBC cyclone	PFBC bed	Spray Dryer
Ag (Silver)	TCLP	<0.024	<0.024	<0.024	<0.024
	Water	0.007	<0.005	<0.005	0.007
As (Arsenic)	TCLP	<0.005	<0.005	<0.005	<0.005
	Water	<0.005	<0.005	<0.005	<0.005
Ba (Barium)	TCLP	0.693	0.141	0.141	0.348
	Water	0.310	0.166	0.202	0.292
Cd (Cadmium)	TCLP	<0.003	<0.003	<0.003	<0.003
	Water	<0.001	<0.001	<0.001	<0.001
Cr (Chromium)	TCLP	<0.005	0.011	<0.005	0.009
	Water	<0.011	<0.011	<0.011	<0.011
Cu (Copper)	TCLP	<0.013	<0.013	<0.013	<0.013
	Water	<0.007	<0.007	<0.007	<0.007
Hg (Mercury)	TCLP	<0.0002	<0.0002	<0.0002	<0.0002
	Water	<0.0002	<0.0002	<0.0002	<0.0002
Ni (Nickel)	TCLP	<0.011	<0.011	<0.011	<0.011
	Water	<0.10	<0.10	<0.10	<0.10
Pb (Lead)	TCLP	0.002	<0.001	<0.001	0.017
	Water	<0.001	<0.001	<0.001	0.012
Se (Selenium)	TCLP	0.005	<0.001	0.001	0.004
	Water	<0.005	<0.005	<0.005	<0.005
Zn (Zinc)	TCLP	<0.006	<0.006	<0.006	<0.006
	Water	<0.006	<0.006	<0.006	0.007
pH	TCLP	12.12	9.58	9.61	11.98
	Water	12.01	11.42	11.77	12.26

Reports in literature indicate that very low concentrations of trace elements most likely present in coal ash are present in the leachates generated from coal ash. The literature also indicates that wastes stabilized with coal ash leach low concentrations of these trace elements.[11]

As with determining hazardousness, the effectiveness of remediation is also often determined using a leaching test. Stabilization and solidification are performed to reduce the leachability or mobility of potentially hazardous constituents to below the point of hazardousness.[11] To find out the likely environmental consequences of utilizing residues, an understanding of the leaching characteristics is required. Knowledge of the morphology and composition of residues may aid prediction of leaching behavior.[16]

When portland cement is compared to quality "F Coal Fly Ash" in the matter of toxic metals that can be acid leached, it is worth noting that the ASTM "F Ash" does as well or better than many commercial portland cements, a material many consider the premier pozzolanic material. Examples of acetic acid (H_2CO_3) extraction testing produced the data given below in Table 8.[7]

TABLE 8: Leaching of Toxic Metals in Portland Cement and "F Fly Ash"

Reagent Name	Arsenic	Barium	Cadmium	Chromium	Cooper	Lead	Mercury	Nickel
Portland Cement Type I	<0.420	0.840	0.010	--	--	0.250	<0.001	--
Portland Cement Type I	<0.010	1.010	<0.010	0.260	0.180	0.260	<0.001	0.020
Portland Cement Type II	<0.010	1.770	<0.010	0.240	0.210	0.340	<0.001	0.020
F Fly Ash	0.030	0.053	<0.005	0.310	0.240	<0.025	<0.0002	0.160

The leaching characteristics of the coal fly ash should be considered before the fly ash is used in stabilization and solidification application. Trace element mobility (leachability) in coal fly ashes can be characterized for individual materials, but not for generalized categories of coal by-products. Each individual coal ash should be assessed for leachability before it is used in a stabilization and solidification process, as a coal fly ash with highly mobile constituents may not be suitable material for hazardous waste stabilization.[11]

Hydration Reactions

When coal fly ash is added to cement, it tends initially to retard the cement hydration reactions, but then accelerate them during most of the reaction. The major reaction between the cement and fly ash is the formation of calcium silicate hydrate caused by the calcium hydroxide in the cement reacting with the glassy silica in the fly ash. The aluminum contained in the glassy portion of the coal fly ash also forms calcium aluminum hydride, or if sulfur is also present, ettringite ($Ca_6Al_2[SO_4]_3[OH]_{12}\cdot 26H_2O$) can also form.

The formation of the mineral ettringite is an important hydration product for many coal fly ashes and other types of coal combustion by-products. It forms when there are sufficient amounts of calcium, aluminum, and sulfur available from the glassy portions of the ash and pH conditions are greater than 11.5.

When coal fly ash is used as a pozzolanic admixture in concrete, it helps remove the calcium hydroxide in the cement that is subject to chemical attack. It is theorized that the calcium silicate levels in the mixture are higher than in plain portland cement, increasing the protective action of the calcium silicate hydrate.[11]

High calcium fly ashes have hydration reactions that result in the formation of ettringite ($Ca_6Al_2[SO_4]_3[OH]_{12}\cdot 26H_2O$); monosulfate ($Ca_4Al_2SO_4[OH]_{12}\cdot 6\text{-}7H_20$); and stratlingite ($Ca_2Al_2SiO_7\cdot 8H_2O$). It has been found that ettringite formation is beneficial and reduces the amount of leachable selenium and boron in contaminated samples of coal fly ash and advanced combustion residues.[11]

Summary Of By-Product Characterization

Mineralogical characterization of crystalline phases provides a means of indentification and quantification. This must be included as a part of a complete characterization scheme for CCT by-products in addition to the nominal bulk chemical analyses and physical tests. In addition to these tests, a determination of the leaching characteristics should also be included. Chemical interactions between mineralogical phases within the coal by-product or other materials it may contact during utilization are key understanding the engineering and chemical behavior of these materials.[10] The scientific experience gained through this study of coal by-products has direct applicability in the development of coal by-products generated from CCT, such as the "The Treatment of Metal-Laden Hazardous Waste with Advanced Clean Coal Technology By-Products."

CONCLUSION

Today there are a variety of by-products produced from coal combustion. Besides fly ash and bottom ash from pulverized coal combustion, which comprise the bulk of coal-use residues, there are residues from many new technologies developed to control the emission of gaseous air pollutants. As electricity production increases and additional flue gas desulfurization treatment plants are fitted to power stations, the quantities of residues are set to increase and produce additional challenges for by-product management.[15]

The exact composition of a dry sulfur sorption by-product is dependent upon the specific process, coal and sorbent compositions, and plant operating conditions. However, upon completing a literature review on CCT by-products, it was found that, in general, these by-products consist of a mixture of conventional fly ash, unspent sorbent (usually lime or dolomite), and the primary reaction product which is anhydrite ($CaSO_4$) or calcium sulfite ($CaSO_3 \cdot 1/2H_2O$). Because of their lime contents, dry sulfur sorption by-products are highly alkaline with calcium carbonate equivalents (CCE) in the range of 40-60% and free or available lime contents of up to 25% CaO. These properties may reflect desirable sorption and cementitious characteristics for use in metal-laden hazardous waste stabilization and solidification.[5]

The successful outcome of this research project offers many benefits. Operators of U.S. coal powered electric plants, who generate about 70,650 kilotons of ash per year[15], would benefit greatly if utilization of the massive amounts of fly ash from these coal-fired plants as reagents could be defined, as it would reduce the quantity and cost of landfilling these residues as wastes. People in the business of remediation of hazardous wastes could also benefit by seeing how coal fly ash chemistries work to reduce the leachability or mobilities of heavy metals such as lead without resorting to "reagent dilution" to achieve meaningful results. A company involved in waste treatment might also be interested in learning what the differences between general classes of coal fly ash are when it comes to toxic control and waste strength properties after treatment. Coal fly ashes are widely available and if it can be demonstrated that the utilization of CCT by-products can result in successful technical results that are cost effective, then the producers of by-products could be linked with the operators of hazardous waste treatment facilities in a mutually beneficial manner, thus meeting the objectives of this research project.[7]

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APPENDIX H

REVIEW OF WASTES AND TREATMENTS

Overview of Stabilization/Solidification Processes

Stabilization and solidification are treatment processes that accomplish one or more of the following: 1) improve the handling and physical characteristics of the waste, as in the sorption of free liquids; 2) decrease the surface area of the waste mass across which transfer or loss of contaminants can occur; and 3) limit the solubility of any hazardous constituents of the waste (either by pH adjustment or sorption phenomena).

Stabilization involves limiting the solubility or mobility of contaminants in a waste. Stabilization usually involves adding materials that will ensure that the hazardous constituents are maintained in their least mobile or toxic form. The addition of lime or sulfide to a metal hydroxide waste to precipitate the metal ions or the addition of a sorbent to an organic waste are examples of stabilization techniques.

Solidification involves the production of a solid block of waste material with high structural integrity. The contaminants do not necessarily interact chemically with reagents, but are instead locked mechanically within the solidified matrix. This is known as microencapsulation. Contaminant loss is limited largely by decreasing the surface area exposed to the environment and/or isolating the contaminants from environmental influences by microencapsulating the waste particles.

Stabilization/solidification is a proven technology for the treatment of hazardous wastes and hazardous waste sites. Specific reasons for the selection of stabilization/solidification as a remediation technology include:

- It improves the handling and physical characteristics of the wastes.
- It reduces transfer or loss of contained pollutants by decreasing the surface area.
- It reduces pollutant solubility in the treated waste, generally by chemical changes.
- Residues from the treatment of hazardous wastes by physical/chemical, biological or incineration technologies can be further treated by stabilization/solidification.
- Because of excavation problems, in situ treatment by stabilization/solidification is the only viable management technique in many cases.
- Alternate hazardous waste treatment and disposal techniques are often economically prohibitive.

There are two basic technologies currently in use to stabilize/solidify inorganic wastes. These are cement-based and pozzolanic stabilization/solidification. Cement-based stabilization/solidification is a process in which waste materials are mixed with portland cement. Water is added to the mixture, if it is not already present in the waste material, to ensure the proper hydration reactions necessary for bonding the cement. The wastes are incorporated into the cement matrix and, in some cases, undergo physical-chemical changes that further reduce their mobility in the waste-cement matrix. Typically, hydroxides of metals are formed which are much less soluble than other ionic species of the metals. Small amounts of fly ash, sodium silicate, bentonite, or proprietary additives are often added to the cement to enhance processing. The final product may vary from a granular, soil-like material to a cohesive solid, depending on the amount of reagent added and the types and amounts of wastes stabilized/solidified.

Pozzolanic stabilization/solidification involves siliceous and aluminosilicate materials, which do not display cementing action alone, but form cementitious substances when combined with lime or cement and water at ambient temperatures. The primary containment mechanism is the physical entrapment of the contaminant in the pozzolan matrix. Examples of common pozzolans are fly ash, pumice, lime kiln dusts, and blast furnace slag. Pozzolans contain significant amounts of silicates, which distinguish them from the lime-based materials. The final product can vary from a soft fine-grained material to a hard cohesive material similar in appearance to cement. Pozzolanic reactions are generally much slower than cement reactions.

One application of stabilization/solidification (SS) technology is in the treatment of metals. More is known about metal SS than about the fixation, destruction, and immobilization of any other hazardous constituent group encountered in SS technology. Metals are the only really hazardous constituents that cannot be destroyed or altered by chemical or thermal methods, and so must be converted into the most insoluble form possible to prevent their reentry into the environment. While this can be done with all metals, the difficulty and cost of such treatment varies greatly with the form of the metal in the waste as well as the amount present.

The presence of metals in the environment is a matter of great concern today. Many are hazardous in one way or another to humans and/or to other forms of life. The hazard to humans may be in the form of acute or chronic toxicity, or the metal may act in more subtle ways, causing cancer and other secondary-effect diseases or damage to fetuses. Aquatic organisms in fresh water or marine environments are often extremely sensitive to very small concentrations of metals. Plant growth may be adversely affected by metals in soils and irrigation water, or may concentrate them in leaves, stems, or roots where they can subsequently affect the food chain. Mammals may be affected both through the food chain and by drinking contaminated water.

The treatment of contaminated soils and other solids is a special case of SS technology. Such wastes are becoming increasingly more important in the SS field as remedial programs become more active. Also, the greater use of incineration is generating residues that are themselves hazardous, usually because of toxic metal content. These wastes are generated in ways very different from the typical waste water treatment sludge, and so their compositions, especially with regard to metal speciation and distribution, are different. Natural soils contain clay, rock, silt, sand, and many natural organic substances. When they become contaminated, it is usually by infiltration of metal species (and other hazardous components) in solution. Such contaminants may originate in accidental spills, from deliberate dumping, or from leaching of older landfills. The interaction of metals with soils is very complex. Adsorption and ion exchange by clay minerals, reaction with insolubilizing anions present in the soil, and complexation by humic substances in the organic fraction of the soil all occur. Complexation may lead either to increased or decreased solubility of the metal, depending on the ligands present.

Inorganic SS systems are used for the chemical treatment of complex wastes with the aim of producing a nontoxic, environmentally safe material that can be used as landfill. The processes use inorganic reagents that react with certain waste components; they also react among themselves to form chemically and mechanically stable solids. These systems are based on reactions between binders, catalysts, and setting agents that occur in a controlled manner to produce a solid matrix. This type of structure displays properties of stability, high melting point, and a rigid structure similar to many soils and rocks.

One of the primary considerations and a criterion in formulating SS systems is that the reagents used in these systems be basically nontoxic and safe to handle. They are formulated from either natural or synthetic materials that have a long history of industrial use and are considered to be generally nonhazardous. The inorganic processes can most meaningfully and conveniently be grouped into two categories: those that use bulking agents, such as Class F flyash, and those that do not. A bulking agent is an addition that primarily adds to the total solids and viscosity of the waste, thus preventing settling out of the suspended waste components before solidification can occur; it may also help produce a solid with better physical properties. Examples of these two groups of processes are (1) cement-based or cement/soluble silicate systems (no bulking agents), and (2) cement/flyash, lime/flyash, cement/clay, or lime/clay (systems with bulking agents). There are two types of bulking agents: those that are essentially inert in the system and those that also have reactive capacity or pozzolanic activity. A pozzolan is a material that does not exhibit cementing ability when used by itself, but in combination with other materials, such as Portland Cement or lime, will interact with these agents resulting in a cementitious reaction.

The most noticeable effect of the difference between systems with and without bulking agents is that systems with bulking agents often have lower chemical costs by virtue of replacing some of the more expensive cementing materials with the less expensive waste products such as flyash. Systems without bulking agents often have lower overall costs because of the lower weight and volume increase associated with them.

In summary, inorganic SS systems are characterized by:

- Relatively low cost
- Good long-term stability, both physically and chemically
- Documented use on a variety of industrial wastes over a period of many years
- Widespread availability of the chemical ingredients
- Ease of use in processing
- Wide range of volume increase
- Inertness to ultraviolet radiation
- High resistance to biodegradation
- Low water solubility
- Relatively low water permeability
- Good mechanical and structural characteristics

Compositions including lime and flyash have comprised the largest volumes of wastes treated in the United States, This is largely due to the use of this technology in the electric power industry to solidify fluegas cleaning sludges from fossil fuel burning power plants. However, lime/flyash processes have also been widely used in other industrial applications at generators' plants, at central treatment facilities, and for remedial projects.

Cementitious reaction products typically are mixtures of gel, semicrystalline, and crystalline structures. Many of the reactions are analogous to those of Portland Cement. In general, however, these reactions are slower than those of cement and do not produce exactly the same products in terms of chemical and physical properties.

Because of the nature of flyash, other differences from cement chemistry are introduced. For example, unburned organics reduce the cementing action by covering reactive surfaces and preventing contact of the cementitious materials. Smaller particles are more reactive (due to larger surface area) than large particles. Some flyashes (Type C) have self-hardening characteristics (contain large quantities of calcium oxide), so that the addition of water alone will produce a cementing action without the addition of lime. This kind of process is claimed to be usable for solidification. However, it depends strongly on the particular flyash being used, and therefore processes combining lime and flyash, and also additions of sulfate, are often necessary to produce a reliable solidification mixture.

Many of the applications, and most of the volume of lime/flyash SS technology have another difference: The wastes being treated contain sulfates and sulfides that enter into pozzolanic reactions in complex reactions that are not fully understood. It is known, however, that the expansive mineral ettringite, is formed in the presence of sulfate.

Lime based and lime/flyash processes are able to accommodate large quantities of organic as well as the more common inorganic sludges. On the other hand, it has been observed that the lime process, in general, is not as effective in reducing the leachability of metals as the cement-based systems. One reason for this is the high pH that usually results from lime-based systems; another may be that these pozzolanic processes do not bring metals such as lead and chromium into the silica matrix as effectively as does cement. However, with any SS process, each waste and disposal scenario must be evaluated separately, and lime/flyash may provide acceptable leaching results in many cases. Materials that interfere with cement hardening and setting may do the same in lime/flyash systems, but the effects are not as common. Lime is often used as an anti-inhibitor for cement setting. Materials that have been found to inhibit lime/flyash processes include sodium borate, calcium sulfate, potassium bichromate, and carbohydrates.

The following page contains several references illustrating the use of fly ash and coal combustion by-product materials for the stabilization/solidification of inorganic and organic hazardous wastes.

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APPENDIX I

REPORTS OF MEETINGS, TELEPHONE CONVERSATIONS, AND VISITS

RECORD OF VISIT TO YUKON PLANT, MSI
NOVEMBER 21, 1994

Present: James Cobb, Ronald Neufeld, Carl Bender, Harry Fleming (Director of Operations) and Carol Kiselich (Laboratory Manager)

Mr. Bender gave Dr. Cobb and Dr. Neufeld a complete tour of the plant. Ms. Kiselich took them through the laboratory facilities. She showed how the treatability studies are conducted and the method by which all paper records are validated and stored. She noted that she maintains a computerized data base of all results and she responded in the affirmative when Dr. Neufeld asked if she could provide the data on treatments with by-products on a disk for transfer to the master file at Pitt, which he will maintain.

One 250-pound sample of a wastewater treatment sludge from a battery manufacturer has been set aside. A small representative sample, made by coring the large sample, will be tested for cadmium and lead. If those two metals fall within the proper range for treatment, the remaining metals will be measured.

One 5-gallon pail of EPC by-product has been delivered.

The measurement of "total metals" in a hazardous waste, made using a digestion in strong acid, followed by an analysis of the metals content of the extract, leaves some undissolved particulate matter behind. It is assumed in regulated practice that any metals remaining in the particulates will not be leachable to a noticeable extent and can be ignored.

Mr. Fleming has extensive experience in construction. He will provide all the equipment and materials required to make the cylindrical samples. He recommends no more than a 2-inch slump and may even try for a 1-inch slump to increase the compressive strengths as high as possible without going to Proctor samples. He will need at least 250 pounds of each by-product to carry out all the solidification tests and recommends 300 pounds of each. The "lump" of material to be sent to Pitt for ASTM leach tests will be the residue from cylinder production.

It was noted that some change in by-product properties might occur during long-term storage. It was recommended that DLC be asked to conduct its usual short list of analyses on one or more samples of by-products stored for some time at the Yukon plant.

The first solidified samples will likely not be ready for sending to Pitt for two months. Cylinders need to be transferred to Pitt as soon as they are prepared. "Lump" and TCLP extracts for additional metals testing can be sent by UPS.

RECORD OF MEETING
NOVEMBER 22, 1994
274 BENEDUM ENGINEERING HALL

Present: James Cobb, David Motak (Associate Director of the Development Office of the School of Engineering) and Kenneth Service (Director of Public Relations for the Office of Public Affairs)

Here is Mr. Motak's memorandum to the Dean of Engineering which recorded that portion of the meeting dealing with our project.

> "Dr. Cobb discussed with Ken two upcoming research awards with which he is currently involved and which he feels could generate interest in the media. One is a $600,000 award from the Department of Energy on the study of hazardous waste. (Mr. Motak attached a copy of my draft news release to the memorandum.) This is a very interdisciplinary program which Dr. Cobb feels can warrant media coverage."

Dr. Cobb will provide Mr. Motak with material from the "Barriers" report which points to the keen interest of the U.S.DOE in the subject of our project. He will re-emphasize the strong desire of MSI in a prompt news release.

RECORD OF MEETING
DECEMBER 1, 1994
1248 BENEDUM ENGINEERING HALL

Present: James Cobb, Emanuel Schreiber, Vourneen Clifford and Jesse Pritts

Quarterly Report

The first quarterly report is due on December 18, 1994. It will cover the period from August 18 through November 18, 1994. It should include:

Background collected during the period on by-product production, properties and utilization (Ms. Clifford)

Background collected during the period on hazardous waste, hazardous waste treatment and waste solidification (Mr. Pritts)

Background collected during the period on other related activities (Dr. Cobb)

General approach to the project, including a brief description of the test plan (Dr. Cobb)

Selection during the period of the fourth by-product and discussion of problems in starting by-product sample collection (Dr. Cobb)

Report of collection by DLC of samples from AES Thames, EPC and Tidd (Mr. Beeghly)

Report of work during the period by MSI (Mr. Bender)

Report of laboratory developments during the period at Pitt, including the laboratory manual, the approach to QA/QC and a flow chart of samples from collection by DLC and MSI through treatment to analysis at Pitt (Dr. Cobb, Dr. Schreiber, Ms. Clifford and Mr. Pritts)

Approach to be used for building and analyzing the data base (Dr. Neufeld)

Plans for the second quarter (Dr. Cobb).

Laboratory Activities

Ms. Clifford and Mr. Pritts are ready to analyze by atomic absorption the ASTM and TCLP extracts from digestion of a fly ash sample from Mr. Latore, one of Dr. Neufeld's students who is studying the properties of light-weight concrete made from fly ash. This is a continuation of the QA/QC initiation of the project.

A sample of two of the by-products - AES Thames and EPC - have been received and analyses can begin on them. Dr. Cobb will examine the test plan and set out the "total metals" requirements. Mr. Latore has used both a strong acid and sodium carbonate to digest his samples for "total metals" and has found that the strong acid digestion leaves a residue. Mr. Pritts will contact Carol Kiselich to obtain her exact method for use in our work. Her method being an acid digestion, we should consider using the sodium carbonate digestion for one or more samples to see the difference.

Miscellaneous Issues

Dr. Cobb reported on the visit he and Dr. Neufeld made to the Yukon Plant. He also mentioned the need for him to prepare a proposal to CSX concerning the AES Thames by-product and to obtain a letter from AEP authorizing collection of the Tidd material.

The "Barriers" report and two documents received from Mr. Beeghly were passed to Ms. Clifford to place in the file.

RECORD OF TELEPHONE CONVERSATION
DECEMBER 2, 1994

Joel Beeghly

Last week Mr. Beeghly picked up two small samples, collected by Duane Maust, and collected one major sample himself. There are now six AES Thames samples at DLC. Dr. Cobb should prepare the proposal to CSX as soon as possible to obtain permission from AES Thames for treating hazardous wastes with its by-product.

CONSOL will collect at least four samples on Saturday, December 3, 1994. Dr. Wu will supervise the collection. The collection was originally scheduled for December 1 when

Mr. Beeghly could observe, but CONSOL had to postpone it. Mr. Beeghly is unavailable to observe on December 3.

The Tidd PFBC is still being brought back on line. Mr. Beeghly would like to have a letter as soon as possible from Mr. Marrocco authorizing collection at Tidd. There is now one Tidd sample in hand at DLC.

Mr. Tutokey has picked up several more samples from EPC. DLC now has four or five samples from that plant.

RECORD OF MEETING
DECEMBER 8, 1994
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Emanuel Schreiber, Vourneen Clifford and Jesse Pritts

Laboratory Work

Another five-gallon sample of EPC by-product has been received from DLC.

Ms. Clifford will order a cylinder of AA-grade acetylene. This led to a general discussion of ordering, tracking and securing gas cylinders. Ms. Clifford's or Mr. Pritts' name will be on all purchase orders along with Dr. Schreiber's to alert the department that these cylinders are to be used on this project.

New Documents

Dr. Cobb distributed copies of discussions that Dr. Neufeld found recently on the environmental electronic bulletin board regarding the new Land Ban regulations. IN the discussions, reference is made to 40 CFR 268, so a dialogue ensued on the promulgation of EPA regulations in the Federal Register, their annual codification in the Code of Federal Regulations and their immediate codification in the Environmental Reporter, which is available in Room 1139 BENDM.

Mr. Pritts has located in Bevier Library an excellent survey from Environment Canada and the EPA on "Investigation of Test Methods for Solidified Waste Evaluation - A Cooperative Program," Report EPS 3/HA/8, January 1991. He will make copies for the group.

Quarterly Report

Mr. Pritts has prepared one flow chart showing the analyses to be performed for by-product samples and another on for treated waste samples in the Pitt laboratories. He has also prepared a two-page report containing an annotated bibliography of six key references on stabilization and solidification of hazardous wastes and a listing of six general references on hazardous and metal-laden waste treatment. He recommends delaying the inclusion of the report he began a while ago on the wastes to be treated at MSI until the next quarterly report. It is not yet clear which wastes MSI will ultimately select.

Ms. Clifford has revised her report on "Characterization of Advanced Clean Coal Technology By-Products" by including changes recommended in her first draft by Dr. Cobb.

Visits by Ms. Clifford

Ms. Clifford will be on personal travel to Maryland on the weekend of December 17-18, 1994 and to the bay area of California during the holidays. She will contact Thomas Blackstock at ACAA and Dean Golden at EPRI to try to arrange visits to ACAA and EPRI for discussions and review of library holdings of interest to our project.

RECORD OF TELEPHONE CONVERSATION
DECEMBER 8, 1994

Steven Bossart

Regarding extra expenses during Phase 1 for collection of 50 tons of Tidd by-product for Phase 2, we are to try to get AEP to provide the funds, as METC's budget is fully committed for FY 1995. If assistance is needed, however, funds can be shifted from Phase 2.

RECORD OF TELEPHONE CONVERSATION
DECEMBER 9, 1994

Joel Beeghly

On Saturday, December 3, 1994 Dr. Wu supervised the drawing of four samples at CONSOL. Five gallons of each of the four samples were provided to DLC. An additional one hundred pounds of one of the samples was drawn and temporarily retained by CONSOL. It will also be provided to DLC in the near future to send to MSI. CONSOL will sample a second train next week. Mr. Beeghly expects to be present at this sampling. He has received an MSDS for the Carneys Point by-product from CONSOL.

An early sample of the EPC by-product, only one bucket of which was provided to MSI, has been discarded and replaced with a 150-pound sample at MSI. Mr. Beeghly is still working on obtaining an MSDS of the EPC by-product.

Mr. Beeghly will obtain six buckets of by-product from Tidd on Monday, December 12, 1994. He is drawing samples from the fly ash silo. This silo is sized to hold one day's production. Mr. Beeghly has obtained the MSDS for this by-product.

RECORD OF MEETING
DECEMBER 15, 1994
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Vourneen Clifford and Jesse Pritts

Laboratory Work

Mr. Pritts will call Ms. Kiselich to learn when to expect the first samples of treated wastes and their TCLP extracts from the Yukon Plant.

Ms. Clifford and Mr. Pritts have established a bound sample log and two bound notebooks for keeping records of their laboratory work. They will create their own Quattro spread-sheet to enter all data into, using the computer laboratory of the Civil and Environmental Engineering Department on the 9th Floor of Benedum Hall.

It was agreed that, for each waste/by-product set, a maximum of one day each would be needed in the Pitt laboratory for (1) simple AA analysis of TCLP extract, (2) hydride analysis of TCLP extract, (3) ASTM leaching, (4) simple AA analysis of ASTM extract, (5) hydride analysis of ASTM extract and (6) QA/QC analyses and data entry. This schedule fills one week of total student time allotted to the project. Thus, forty weeks (approximately ten months) would be required. It is expected that few samples will require full analysis, so this schedule will be reduced considerably. It is likely that this would reasonably fit into the thirty-four weeks (eight-and-a-half months) that remain in Phase One (January through mid-August). Added to this schedule will be the breaking of the cylinders and four ASTM extractions, and may be eight digestions and metals analyses for by-products, eight TCLP extractions of these same samples and any special activities. The time for these additional activities can be obtained from use of work-study students and from postponement of some analyses to Phase Two, if necessary.

Background Survey

Ms. Clifford has received a list of reports on advanced SO_2 control by-products from Dean Golden of EPRI. She is still trying to reach Mr. Blackstock of ACAA to visit there on December 19, 1994. Mr. Golden reports that no EPRI staff will be in their offices during the period between Christmas and New Years, so she cannot visit there at that time. Ms. Clifford and Mr. Pritts will continue to work on their white papers on by-products and on waste and waste treatment in the new year.

Requests for Formal Approvals of By-Product Use

Dr. Cobb reported that he has written to Mario Marrocco and Thomas King, requesting written approvals of the use of the Tidd and AES Thames by-products, respectively.

Quarterly Report

Ms. Clifford has added three pages to her report on "Characterization of Advanced Clean Coal Technology By-Products." It is ready to be included in the quarterly report.

RECORD OF TELEPHONE CONVERSATION
DECEMBER 16, 1994

Joel Beeghly

Mr. Beeghly is delivering a large sample each of the by-products from CONSOL and Tidd to the Yukon Plant of MSI, and he will also deliver to Yukon another large sample of by-product from EPC. He will send four more buckets of by-products to Pitt by UPS.

Mr. Beeghly had expected that CONSOL would have sampled another train today, but Dr. Wu said this week's train arrived unexpectedly on Wednesday and could not be sampled that day. Dr. Wu also said that the free base of the first samples last week measured 3-4. He is used to seeing values around 6.

Mr. Beeghly plans to collect at least two samples per week from Tidd from this point, considering that it will likely be ceasing operation in February. He has a line on some super-sacks to collect the Phase Two sample from Tidd, but still needs authorization from DLC to use them and from AEP to fill them at Tidd. He also needs a date on which he can fill them. Dr. Cobb will contact Mr. Marrocco to find out when the letter from AEP will be coming and with whom Mr. Beeghly should coordinate the Phase Two sample collection.

Mr. Beeghly expects to collect a fifth sample from EPC soon. On December 12, 1994 Gary Anderson called to ask for the results of DLC's pH analyses of the first samples obtained from the plant. Mr. Beeghly reported that two were near 12.4 but one was at 12.52, which is .02 higher than the limit above which the by-product becomes classified as hazardous. It reached this high value, even though the free lime was only 3%. Mr.Anderson had hoped that DLC's value for this one sample would have been 12.5 or lower so that EPC could have argued that that batch of by-product was really not hazardous.

Dr. Cobb will also talk with Mr. King about the timing of the approval for use of the by-product from AES Thames on the project.

RECORD OF TELEPHONE CONVERSATIONS
DECEMBER 19, 1994

Mario Marrocco

Mr. Marrocco has forwarded both letter to Ms. Susanne Buckley of AEP's Environmental Engineering Department, asking her to prepare AEP's written response to them. He suggested that Mr. Beeghly speak with Mr. Steven Burge, the plant manager at Tidd, to make sure he knows about the project, about the sampling that we are doing, and about our need for storage and transportation of the Phase Two sample.

Joel Beeghly

Dr. Cobb passed the information from Mr. Marrocco on to Mr. Beeghly.

Thomas King

Mr. King has FAXed our letter to JTM and to AES Thames, but he has spoken only with JTM about it. JTM agrees that the authority to use the by-product in our project rests with AES. Unfortunately, JTM's new contract to manage the by-product from AES Thames is just starting and JTM feels it needs a month or so of experience before approaching AES about our project. In addition, there are some management changes occurring at AES Thames that won't be settled down until mid-January. Mr. King recommended that we wait until the fourth week of January before sending a copy of the quarterly report to Mr. Boucher and then ask Mr. King to initiate calls about our request.

RECORD OF TELEPHONE CONVERSATION
DECEMBER 27, 1994

Carl Bender

Mr. Bender will be at the Yukon Plant tomorrow and will speak with Ms. Kiselich about her schedule for conducting the first treatments of hazardous wastes with by-products. She has collected four or five wastes and is characterizing them to see if they meet MSI's basic criteria for acceptance.

RECORD OF TELEPHONE CONVERSATION
DECEMBER 29, 1994

Joel Beeghly

Dr. Cobb asked about the method to be used to sample the buckets of by-product which have been received by Pitt from DLC. Mr. Beeghly responded that, because the by-product is very fine, it may be considered homogeneous and a sample may be drawn from any part of the bucket. Only solids having large particles need be quartered or riffled.

Dr. Cobb asked for a review of the samples sent to MSI and to Pitt. MSI has received three bulk samples of by-product from EPC and one each from CONSOL and Tidd. DLC has asked that the first EPC sample received by MSI was discarded. The third EPC sample to MSI was simply a backup. Later today, Dr. Cobb will inventory the buckets received at Pitt. When Mr. Tutokey returns on Tuesday, January 3, 1995, we can make a careful record of each sample and its disposal.

DLC has collected two bulk samples of the AES Thames by-product from the Albright site.

Mr. Beeghly has spoken by telephone with Ms. Buckley and Mr. Burge about sampling at Tidd. Ms. Buckley is still working on our letter. Mr. Beeghly notes that trucks have been loaded out with Tidd by-product but no one has filled super-sacks there before. Therefore, some new rigging will have to be done at the fill station.

RECORD OF TELEPHONE CONVERSATION
JANUARY 4, 1995

Joel Beeghly

Mr. Tutokey is preparing a list of all samples collected to date. Mr. Beeghly and Dr. Cobb will review the list to identify tests for each specific sample, according to the test plan.

Two more samples have been collected by CONSOL, bringing the number of samples from CONSOL to six so far. Next week will see the final shipments by CSX to Albright from AES. Mr. Maust will try to finish collecting all ten samples before the last car from AES Thames is unloaded. Mr. Beeghly is working with the staff at Tidd to install a new nozzle for use in filling the super-sacks. The super-sacks are coated so that they can be stacked on pallets outdoors under a tarp. Mr. Beeghly will talk with Mr. Bender about storing the 50 tons of Tidd by-product at the Yukon Plant.

Mr. Beeghly identified EPC Sample # 3 as the one for MSI to use to treat hazardous waste at the Yukon Plant in Phase One. Dr. Cobb will communicate this to Mr. Bender.

RECORD OF MEETING
JANUARY 5, 1995
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Emanuel Schreiber, Vourneen Clifford and Jesse Pritts

Laboratory Work

Mr. Pritts and Ms. Clifford will continue preparing standards and getting ready for the identification of the by-product samples for extraction and the arrival of the first samples and extracts from MSI.

Background Survey

Ms. Clifford has reviewed the list of reports on advanced SO_2 control by-products which she received before Christmas from Mr. Golden of EPRI. She has identified papers from the list which she has requested Mr. Golden to send to her. She is trying to reach Mr. Blackstock of ACAA to request more papers from him. She would like to visit there again after the library is restored following their move and the computerized listing of library holdings is available. ACAA is holding a major conference in a few weeks, which Mr. Beeghly will attend. Ms. Clifford will examine the proceedings when Mr. Beeghly returns from the conference.

By-Product Collection

Dr. Cobb reviewed the report he received from Mr. Beeghly on January 4, 1995 on the status of by-product collection.

RECORD OF TELEPHONE CONVERSATIONS
JANUARY 5, 1995

Carl Bender

Dr. Cobb noted that the EPC Sample # 3 should be used for the Phase One work at MSI.

Ms. Kiselich will send representative samples of the four by-products to Antech and to Pitt for analysis. She will extract the four by-product samples by Monday, January 9, 1995. The extracts will be sent to Antech and to Pitt. At Pitt graphite furnace analyses for the four metals of interest that must be analyzed by this method will be conducted.

Ms. Kiselich will begin testing waste samples to see if they fail the TCLP test and thus are identifiable as being acceptable for treatment at MSI. As soon as they are so identified, laboratory treatments will be conducted with the three by-products (**NOT** including the AES Thames by-product). The first extracts, "lumps", and cylinders should be available for sending to Pitt by January 19, 1995.

RECORD OF TELEPHONE CONVERSATIONS
JANUARY 6, 1995

Joel Beeghly

Page 14 of the test plan (10/17/94 version) defines the TCLP and ASTM leachings to be performed in Phase One of our project. Four samples will be analyzed for TCLP by MSI - AES Thames # 4, EPC # 3, Tidd # 2 and CONSOL # 1. These four samples will also be analyzed by the ASTM leaching test at Pitt. Eight other samples will be analyzed fully by DLC. Four of these are the AES Thames # 2, # 4 and # 7 and the EPC # 4 and #5. The other four will be identified as they are collected. Pitt will perform TCLP leachings of these samples, if funds are available. Mr. Beeghly expressed particular interest in TCLP's for the two additional samples from the EPC. Other studies with which he is familiar have found higher levels of arsenic in leachates produced using by-products from units burning gob, which is high in pyrites. There appears to be a pyritic form of arsenic which contaminates some coals.

For all of the samples collected by DLC, Pitt will obtain operating conditions during their production from the four plants which generated them.

Mr. Beeghly will take a sample super-sack to Tidd as soon as he receives it so that an adapter can be made to fill super-sacks there. Half of the sacks (approximately 20) will be filled in one day and trucked to storage (hopefully at MSI) and the other half filled and transported another day. Mr. Beeghly will talk later today with Mr. Bender about storage of the super-sacks (hopefully at the Yukon Plant).

Steven Bossart

Mr. Bossart is preparing a report on the Fossil Energy Waste Management Program. For it he wishes several references to reports generated on each project or, for new projects such as ours, reports of related work. Dr. Cobb agreed to provide bibliographic material for three articles from the Pitt project team.

Mr. Bossart and Dr. Cobb reviewed the rationale for the amount of Tidd by-product being collected for Phase Two.

Carol Kiselich

Ms. Kiselich has conducted TCLP leachings of all four by-product samples. Leachates and small amounts of the by-products are available for pickup and transporting to Pitt.

Ms. Kiselich has identified seven candidate wastes. She has conducted TCLP leachings of all seven and today has sent small amounts to Antech for digestion for total metals analysis. She will talk with Antech on Monday, January 9, 1995 about provision of aqueous extracts to Pitt for analysis of the other metals of concern (copper, nickel and zinc).

RECORD OF TELEPHONE CONVERSATION
JANUARY 9, 1995

Ronald Neufeld

Dr. Vallejo can provide a copy of the article from the April 1994 issue of the Journal of the ASCE - Energy Division on the evaluation of light-weight block, which can be referenced in the list of related projects to be sent to Mr. Bossart.

RECORD OF MEETING
JANUARY 11, 1995
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Vourneen Clifford and Jesse Pritts

Laboratory Work

Mr. Pritts and Ms. Clifford have begun the ASTM leaching of the same four by-products that are being analyzed and will be used by MSI. They are also preparing a spiking solution. The first attempt at preparing this solution resulted in a precipitate of silver chloride. The second formulation will exclude silver.

Background Survey

Documentation of operating conditions during production of the by-products samples received by the project team was discussed. Except for those from EPC, we will await the collection of all samples and then request operating conditions during the production of all of them. EPC has sent DLC a copy of the operating conditions along with each sample. Ms. Clifford will ask Mr. Beeghly to send a copy of the sheets that have been collected to date, which she will use to begin constructing a detailed summary containing a table of conditions and a narrative for the next quarterly report. Assistance will be sought from Mr. Anderson at the plant when questions arise about the configuration of the unit, the location of sensors, and the interpretation of data points.

Mr. Pritts will continue to review the literature on hazardous waste treatment, but he will await the identification by MSI of the first wastes selected, before reviewing the general methods used to produce those wastes.

Related References for Mr. Bossart

Mr. Bossart has requested several references for his review of Fossil Energy Environmental Management projects. Dr. Cobb will send three references to him.

RECORD OF TELEPHONE CONVERSATIONS
JANUARY 13, 1995

Joel Beegly

Two new samples have been collected by CONSOL. This brings to six the number of samples collected by CONSOL so far.

No new samples have been collected at the Albright Mine recently. We still need three additional samples of the AES Thames material. Forty railcars have just arrived at the mine and Mr. Maust hopes that at least three of them will contain by-product from AES Thames. If so, he will collect the three final samples and that portion of the program will be complete. If not and the last railcars with this by-product have already been delivered there, we will have to arrange for the final three samples to be obtained at the Porter site.

Tidd was shut down on January 2, 1995 and is expected to have resumed operation on January 12, 1995. Mr. Bender does not have a permit to allow storage of the super-sacks at the Yukon Plant. Mr. Beeghly will recontact Tidd to see if they can be stored at the landfill site where the Tidd ash is now being disposed. His fallback position is to store the super-sacks at DLC.

RECORD OF MEETING
JANUARY 18, 1995
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Vourneen Clifford and Jesse Pritts

Laboratory Work

Mr. Pritts and Ms. Clifford have completed the ASTM extraction of the four by-product samples. They will perform the AA analyses on the extracts next. They need to discuss with Dr. Schreiber the methods for using the graphite furnace for analyses of antimony, beryllium, thallium and vanadium and hydrides for the analyses of arsenic and selenium.

By-Product Collection

Dr. Cobb reported on his conversation with Mr. Beeghly on January 13, 1995.

Hazardous Waste Treatment

Dr. Cobb will speak with Ms. Kiselich today or tomorrow about picking up the extracts from the TCLPs of the by-products and the first wastes. He will arrange a time to go to the Yukon Plant that will allow Ms. Clifford and Mr. Pritts to accompany him.

RECORD OF VISIT
JANUARY 23, 1995
YUKON PLANT, MSI

Present: James Cobb, Vourneen Clifford, Jesse Pritts and Carol Kiselich

Dr. Cobb pointed out the major features of the Yukon Plant from the roadway leading to the office and laboratory. Ms. Kiselich gave a brief overview of the facility and a tour of the laboratory building. TCLP extracts of all four by-product samples and of seven candidate hazardous waste samples, samples of all four by-products themselves, and three blanks were picked up for transporting to Pitt. MSI is still awaiting the results of Antech's analysis of the seven hazardous waste extracts to decide which ones are acceptable for our project.

RECORD OF TELEPHONE CONVERSATION
JANUARY 24, 1995

Joel Beeghly

Mr. Beeghly attended the meeting of the American Coal Ash Association last week. There he talked with other attendees from Allegheny Power System, Department of Energy, Duquesne Light Company, GAI Associates and SEEK.

The DLC analytical laboratory is working on by-product characterizations. Mr. Maust is on the lookout for three more rail cars of by-product from AES Thames. He will collect the last three samples for us when he locates them.

Tidd has been down since January 2, 1995. When it starts back up, it will run through the end of March. A new problem has arisen in the collection of the 50-ton sample for Phase II. The temperature of the by-product in the storage silo is between 300°F and 400°F in order to prevent condensation. The super-sacks cannot tolerate temperatures that high. Three approaches have been considered.

> Mr. Beeghly has talked with individuals from SEEK about using their system to collect the by-product from the silo, but he feels that a less expensive approach ought to be found.

AEP has a pneumatic truck on standby at Tidd which has been loaded with other materials used in the process, but not yet with by-product. It could be used for temporary storage while the by-product cools. It could then be unloaded using airpads. However, this requires super-sacks with a vent for transport air. Significant dust may escape with the air, but this could be cleaned by passing it through peat moss.

DLC could seek the use of a separate silo somewhere into which to blow the by-product from the pneumatic truck. From the silo the super-sacks could be easily bagged by gravity flow from the silo.

Mr. Beeghly will give all this more thought and investigation.

RECORD OF MEETING
JANUARY 24, 1995
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Vourneen Clifford and Jesse Pritts

By-Products

Dr. Cobb reported on his conversation with Mr. Beeghly earlier in the day. He hopes to go to DLC next week to begin examining the data that is being generated there and to see the proceedings of the ACAA meeting. Dean Golden of EPRI is sending a copy of a report on "Properties of Pressurized FBC Ashes" to Mr. Pritts. He is also sending Mr. Pritts a copy of a report on the treatment of hazardous wastes using AFBC by-products, produced by the Western Research Institute at Laramie, Wyoming.

Laboratory Work

Mr. Pritts will check on the chain-of-custody documents for the samples obtained yesterday from MSI.

The method of analyses of the fifteen metals of interest: 8 TCLP metals (Ag, As, Ba, Cd, Cr, Hg, Pb, Se), eight standard additional metals (Cu, Zn, Ni) and 4 special metals (Be. Tl, Sb, V) - were discussed. Eight will be done by AA (Ag, Ba, Cd, Cr, Cu, Ni, Pb, Zn), four by graphite furnace (Be, Sb, Tl, V), two by hydride (As, Se) and one by cold vapor (Hg). Ms. Clifford and Mr. Pritts will discuss with Dr. Schreiber the methods for using the graphite furnace, the hydrides and cold vapor.

Mr. Pritts and Ms. Clifford now have an ASTM extract (which they prepared) and a TCLP extract (prepared by Ms. Kiselich) of each of the four by-product samples. They will perform the AA analyses on the eight extracts next.

RECORD OF TELEPHONE CONVERSATION
FEBRUARY 1, 1995

Carol Kiselich

Four of the seven hazardous wastes, whose extracts were sent to Antech two weeks ago, have been selected for use in Phase I. Two of the seven have been rejected. One is still under consideration; it will be compared with another hazardous waste to be analyzed in the future and either selected or rejected. Samples of the four selected hazardous wastes were sent yesterday to Antech for full digestion and extraction for determination of total metal content. Ms. Kiselich will request that a portion of the extract be provided to Pitt for analysis of the four special metals.

Two new hazardous wastes have been identified and are beginning through the evaluation process.

As soon as the total metals are known for the four selected hazardous wastes, treatments at the 10/90, 30/70 and 50/50 ratios of by-product/waste will be conducted using the four wastes and three of the four by-products (excluding for the moment the AES Thames material). TCLP extracts will be made of the fresh and day-old treatment products. The best recipe will be repeated to produce cylinders and the extra mass to send to Pitt for strength and ASTM testing.

RECORD OF MEETING
FEBRUARY 1, 1995
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Vourneen Clifford and Jesse Pritts

Hazardous Wastes

Dr. Cobb reported on his conversation earlier today with Ms. Kiselich.

Literature

The two reports promised by Dean Golden of EPRI have arrived. The one describing WRI's work on waste stabilization is excellent and parallels our project very closely. A bibliography on FGD, published in October 1993, has also been received from the Bureau of Mines. Ms. Clifford is going through it to seek pertinent references.

Laboratory Work

The laboratory results will be built in layered fashion. The first layer will be the total metals analyses of the ten hazardous wastes and the four by-products. These analyses will determine which metals will be sought in the extracts from the treated samples. The second layer will be analyses of the TCLP extracts of these fourteen materials. These analyses will be used to (1) demonstrate that the wastes are hazardous and the by-products are non-hazardous, and to determine what metals may be contributed by the by-products. The third layer will be the 120 waste samples, obtained by treating each of the ten wastes with each of the four by-products at ratios of 10/90, 30/70 and 50/50 by-product/waste. Analyses of the TCLP extracts of these samples will determine which level of treatment is optimal. The fourth layer will be the evaluation of the 40 optimal waste/by-product pairs for strength, for leachability under the ASTM protocol, and possibly for other parameters.

By careful management of the extract samples in the Pitt laboratory, a reasonable minimum of analyses of both extracts and QA/QC samples will be conducted.

Process Information

The group discussed the opportunity for comprehensive evaluation of the variation in properties of by-products studied in this project and of the effect of operating parameters on these properties. As we understand this better, we might search the literature for the properties of by-products other than the four we are using, and then contact their producers to obtain the operating parameters during their production. This would be a valuable scholarly addition to our study.

RECORD OF TELEPHONE CONVERSATION
FEBRUARY 1, 1995

Joel Beeghly

All ten of the AES Thames samples have been collected. Mr. Mause has the car dates for the final samples. DLC still needs to obtain the dates from him.

Tidd is back up and running, but determining a method to collect and store the 50-ton sample for Phase II is proving difficult. Neither AEP or MSI can store it. DLC may be able to store it if assurances can be obtained that it will be moved from there eventually.We might speak with MSI about ultimately disposing of it if it is not all used. This ought not to be an insurmountable problem.

As to collecting the by-product from the hot silo at Tidd, it could be transferred to metal drums for cooling and then to super-sacks, but doing so would be tedious and expensive. It appears much better to transfer by-product to the pneumatic truck at Tidd. AEP would probably allow the cooled by-product to be transferred at the landfill site from the truck directly to the bags, but there are concerns both for the ability of the super-sacks to withstand the stress caused by a possibly high rate of flow from the truck and for the control of dust from the operation. A test of filling one or two super-sacks might be run to test this out, but that would be cumbersome. Another approach would be to find an available silo as an intermediate step between the truck and the super-sacks. Mr. Beeghly has a few ideas about where a silo might be found and offered. The best approach may be to approach a commercial bagger, such as the firm DLC has used before in SE Indiana. Mr. Beeghly will speak with this firm to obtain their thoughts, especially a referral to a closer bagger. A final approach might be to ask AEP to let the last batch of their final run at Tidd to cool down in the silo and then be drawn off directly into the super-sacks. This would provide Tidd with a test of the severity of the potential for condensation and solidification of cooled by-product in the silo.

After Mr. Beeghly obtains information from the bagger in Indiana, Dr. Cobb will contact Mr. Bender and Mr. Marrocco about some of the suggestions noted in the last paragraph and the possibility of funding from AEP for transporting the by-product for bagging and storage.

RECORD OF TELEPHONE CONVERSATIONS
FEBRUARY 3, 1995

Joel Beeghly

Several items for background were discussed.

The by-product directly from production plant silos is generally hot (300-400°F). Little cooling is seen during transportation. Will commercial users of by-product, such as MSI, be able to receive material at this temperature? If not, what will be the cost of introducing coolers, either at the production site or at the user's facility?

Many users of materials similar to the by-products we are studying want the material delivered commercially in super-sacks.

Tidd is not the only AEP plant with a heated ash silo to assure that moisture does not condense and lead to ash set-up. The AEP plant at Rockport, Indiana, at which western coal is burned, also has one for the Class C fly ash produced there. Class C fly ash is used by AEP to make a 20% Class C/80% Class F mixture called Flash Fill, which is a non-portland cement-based flowable fill sold commercially.

Carl Bender

MSI can receive any excess Tidd by-product, stored by DLC and unused in Phase II of the project. It would be disposed at the Yukon Plant, not at the non-hazardous landfill. Mr. Bender did not elaborate on the reason for this. MSI would want a manifest of the Tidd by-product when it would be shipped from DLC. [This response was passed to Mr. Beeghly on February 6, 1995.]

RECORD OF MEETING
FEBRUARY 8, 1995
1139 BENEDUM ENGINEERING HALL

Present: James Cobb, Emanuel Schreiber, Vourneen Clifford and Jesse Pritts

By-Products

Dr. Cobb reported on his conversation with Mr. Beeghly since the last meeting. Dr. Cobb still needs to prepare the requests for AES and JTM for use of the AES Thames by-product. Dr. Cobb and Ms. Clifford will meet later today to examine the operating data from EPC and to discuss the need for further information.

Laboratory Work

Later today Ms. Clifford and Mr. Pritts will begin the AA analyses on the eight extracts they have collected. They will also digest samples of the four by-products during the coming week. The first samples from MSI should arrive within two weeks.

Dr. Schreiber will work with Ms. Clifford and Mr. Pritts to set up a Quatropro database for the by-product analyses. The group had considerable discussion on this activity.

Second Quarterly Report

Ms. Clifford will obtain the computer draft of the QA/QC Program from Dr. Cobb in order to revise and update it for the next draft of the Laboratory Manual. This activity will be described in the second quarterly report. Also in that report will be a comprehensive by-product database and analysis. The first comprehensive database of treated wastes will not be presented until the third quarterly report; in fact, there will be much less in the second quarterly report on waste treatment than had been hoped for at the beginning of the second quarter, because of the unexpectedly long time needed to evaluate each treatment recipe before final samples can be produced by MSI. Dr. Cobb will outline the second quarterly report and prepare a detailed description of how samples flow through the project.

RECORD OF MEETING
FEBRUARY 8, 1995
1137 BENEDUM ENGINEERING HALL

Present: James Cobb, Joel Beeghly (briefly by telephone) and Vourneen Clifford

Dr. Cobb and Ms. Clifford examined the operating data from EPC and became familiar with all of the parameters and values. It was decided to await the first analytical results from DLC which will show the variability of by-product properties. If the variations are relatively small, only the average values of a few additional parameters will be needed from the EPC. If the variations are large, much more information will be sought in order to determine the contribution of variation by a number of parameters. Mr. Beeghly will FAX to Pitt the results which he obtained from the DLC analysts on February 7, 1995 and is just starting to review himself. Dr. Cobb and Ms. Clifford will meet again tomorrow to evaluate the variability of the DLC results and to talk again with Mr. Beeghly.

RECORD OF TELEPHONE CONVERSATION
FEBRUARY 8, 1995

Mark Boucher (AES Thames River Plant)

I reported that I was preparing a letter to him and to Grover Dobbins requesting permission to use the Thames River by-product. He felt that the lines of approval would go as follows:

> JTM would tell CSX that they want to have the by-product used in the project;
> CSX would say OK if AES says OK;
> JTM would then tell AES that they want to have the by-product used in the project;
> AES would say OK.

[In my correspondence with CSX, JTM and AES I will leave it to Mr. King of CSX to initiate the action, however the flow actually goes, because he has been my principal point of contact, as indicated by Anker Energy.]

Mr. Boucher was also concerned about indemnification. He felt that we (DOE and Pitt) will indemnify CSX and CSX would then indemnify AES via JTM.

RECORD OF TELEPHONE CONVERSATION
FEBRUARY 9, 1995

Joel Beeghly

A review of the results FAXed to Pitt on the first four EPC samples showed very little variation between the first three of them. The fourth is finer and lighter. Mr. Beeghly will explore the difference between "1:1" and "1:4" indications in the "temperature rise" parameter.

The mixed ratio is the number of pounds of by-product which will solidify one gallon of water in one-half to one hour. The values for the EPC by-product are equivalent to those for a by-product from a petroleum coke combustor, which has more quick-lime but more dead-burned (non-hydratable) calcium sulfate. Active anhydrite ($CaSO_4$) hydrates first to hemihydrate (plaster of paris) and then to dihydrate (gypsum).

The sample collection stands at ten from AES Thames (that completes this source), six each from CONSOL and EPC, and seven from Tidd. About half of these will be fully analyzed by the end of next week (the end of the second quarter of the project).

RECORD OF TELEPHONE CONVERSATION
FEBRUARY 14, 1995

Joel Beeghly

There is a good window next week for bagging the Tidd Phase Two by-product at Aimcor in Aurora, Indiana. Aimcor cannot do it in March because of other commitments. They will charge $65/ton, including about $20/ton for super-sacks and pallets.

Bulk Transit will provide the pneumatic tanker truck at $27.52/ton to transport the by-product to Aurora. It will also provide the flatbed truck at $30.60/ton to bring the filled super-sacks on pallets back to DLC in Pittsburgh.

The total cost for the job is $123.19/ton or $6160. If Tidd could have shipped the by-product directly to MSI's Yukon Plant, the cost would have been about $1500. It will cost about $500 to ship the super-sacks from DLC to the Yukon Plant next fall.

Mr. Beeghly will have a company representative from Dayton, Ohio observe the bagging at Aimcor. He will observe the transfer from the silo to the pneumatic tanker truck at Tidd himself. Scott Renniger from METC is scheduled to be at Tidd early next week and may be able to observe the transfer there also.

Dr. Cobb agreed to report this to Mr. Bossart and to obtain METC's approval.

RECORD OF TELEPHONE CONVERSATIONS
FEBRUARY 15, 1995

Steven Bossart

Mr. Bossart has reviewed the information sent to him by FAX yesterday by Dr. Cobb. He gave his oral approval for the collection of the Phase Two sample of Tidd by-product as outlined. He asked Dr. Cobb to prepare a letter to the Contract Specialist stating what is to be done, the rationale for it, its cost and how the cost will be covered by AEP and Phase Two of our contract.

Mr. Bossart reported that the Morgantown Fluid Bed Combustor has transferred dry, hot by-product pneumatically first to tanker trucks and then from tanker trucks to final sites. Courtney Black from WVU has much familiarity with this procedure and the people who are doing it. He may be reached at (304)293-2867, ext. 447. A colleague of his, Paul Zimkavich, is also familiar with it. He may be reached at extension 441 at the same number.

Mario Marrocco

Mr. Marrocco felt that a $2,000 request for support from AEP was reasonable. He suggested sending it to Suzanne Buckley and that it be principally in the form of a prepayment of the freight charges to ship the by-product to Indiana. He suggested that the request for the prepayment be made to Steven Burge, the Tidd plant manager, for him to send on to Ms. Buckley.

Joel Beeghly

Mr. Beeghly discussed the method for transferring the by-product from the silo through an existing "elephant trunk". When this device was used for a first and only time in September 1991 it was found to be plugged through non-use and had to be cleared. Several weeks ago an inspection found something wrong with the "elephant trunk" and the station's personnel indicated they were going to work on it.

Mr. Beeghly noted for the general record that dolomitic lime is used at Tidd because the magnesium in the bed material prevents deposits around the tuyeres.

RECORD OF MEETING
FEBRUARY 15, 1995
1139 BENEDUM ENGINEERING HALL

Present: Emanuel Schreiber, Vourneen Clifford and Jesse Pritts

Laboratory Work

A brief discussion was held.

RECORD OF TELEPHONE CONVERSATIONS
FEBRUARY 16, 1995

Suzanne Buckley

Ms. Buckley left a message that we should "bill the plant directly. Don't send [it] to anyone's attention."

Joel Beeghly

The message from Ms. Buckley was transmitted to him.